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Water Resource Data and Preliminary Trend Analysis for the Highland Silver Lake Monitoring and Evaluation Project Madison County, Illinois, Phase 1

Illinois State Environmental Protection Agency
Springfield

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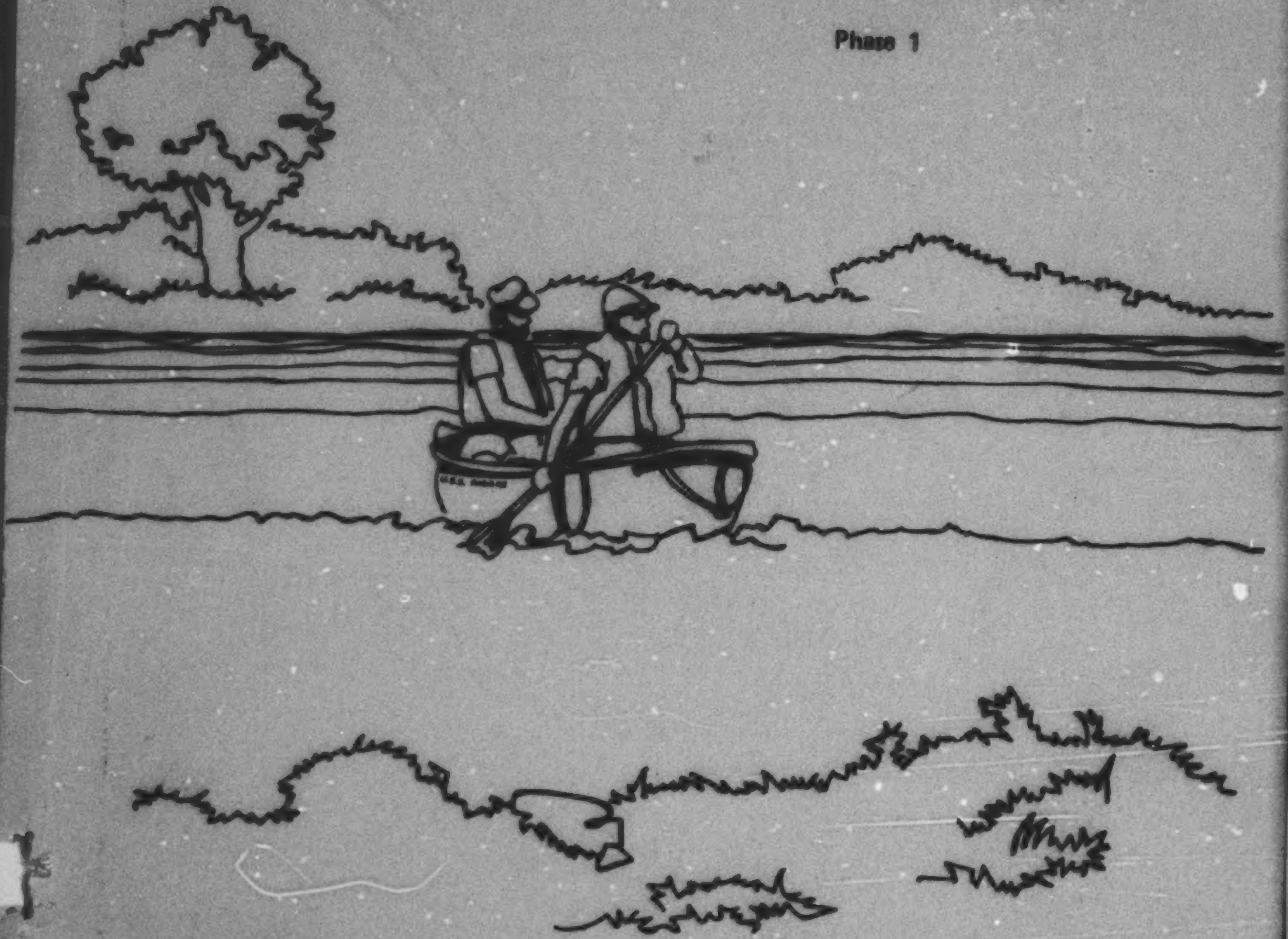
Water Resource Data and Preliminary Trend Analysis for the Highland Silver Lake Monitoring and Evaluation Project

Madison County, Illinois

Phase 1



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This report is a product of Comprehensive Monitoring and Evaluation Program for Highland Silver Lake Watershed. The purpose of this report is to present and briefly interpert trends in water quality data collected from project inception thru March 31, 1982 as part of the Highland Silver Lake project. The primary purpose of this monitoring and evaluation project is to determine the impacts of the Rural Clean Water Project on the water resources of the watershed. The observations and explanations are only preliminary in nature and should not be considered absolute conclusions.

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Water Resource Data and Preliminary Trend Analysis for the Highland Silver Lake Monitoring and Evaluation Project, Madison County, Illinois

Phase 1

written by

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November, 1982

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Table of Contents

Page

I. Executive Summary 1

II. Perspective 4

III. Introduction 5

IV. Description of Highland Silver Creek Watershed 5

V. Purpose of Special Monitoring and Evaluation 8

- 1. Water Quality Problems 8
- 2. Water Quality Improvement Goals 9

VI. Monitoring Strategy 9

VII. Description of Monitoring Stations 10

- 1. Tributary Stations 10
- 2. Field Site Monitoring Stations 10

VIII. Monitoring Methods 21

- 1. Precipitation Measurements 21
- 2. Flow Measurements 23
- 3. Water Quality Sampling 24
- 4. Biological Sampling 25
- 5. Lake Water Quality Sampling 27
- 6. Laboratory Procedures 29
- 7. Data Management 29
- 8. Data Analysis 30

IX. Results and Discussion 30

- 1. Watershed 31
  - A. Land Treatment 31
  - B. Precipitation 32
  - C. Streamflow 33
- 2. Stream Water Quality 34
  - A. Suspended Matter 34
  - B. Nutrients 36
    - i. Phosphorus 37
      - a) Total Phosphorus 38
      - b) Dissolved Phosphorus 38
    - ii. Nitrogen 38

Page

a) Total Kjeldahl Nitrogen 39
b) Nitrates-Nitrites 39
c) Ammonia 40

C. Heavy Metals and Related Trace Elements 40
D. Fecal 41
E. Organic Matter Demand 42
F. Temperature 43
G. Conductivity 43
H. Dissolved Oxygen 43
I. pH 44

2. Field Monitoring 44

A. Suspended Material 46
B. Total Kjehdahl Nitrogen 46
C. Total Phosphorus 47
D. Organic Matter Demand 47

3. Lake Monitoring 47

A. Lake Quality: Introduction 48
B. Volunteer Lake Monitoring 49
C. Turbidity at the Highland Silver Water Treatment Plant 49
D. Lake Water Quality 51

i. Total Suspended Solids 51
ii. Turbidity 57
iii. Transparency 61
iv. Nitrogen 61
v. Phosphorus 68
vi. Chemical Oxygen Demand 73
vii. Fecal Coliform 74
viii. Chlorophyll 75
ix. Temperature 76
x. Dissolved Oxygen 78
xi. pH 80
xii. Total Alkalinity 83
xiii. Conductivity and Total Dissolved Solids 85

E. Lake Classification and Trophic State 87

F. Lake Water Quality: Overview 91

X. List of publications pertaining to Highland Silver Lake Watershed Project 93

XI. Literature Cited 94

Page

XII. Appendix Section 99

a. Laboratory Analyses 100
b. Tolerance Classification 102
c. Stream Classification 101
d. Lake Water Quality Information 103
e. Watershed Water Quality Information 120
f. Field Water Quality Information 122

List of Tables

Page

1. Land use/cover in the Highland Silver Lake Watershed, 1981, by acres and percent. 6
2. Outline of sampling protocol for Highland Silver Lake Waterhsed. 13
3. Drainage area, soils and conservation practice for each field monitoring site. 14
4. Land treatment accomplishments in the Highland Silver Lake RCWP. 32
5. Monthly measured and historic precipitation averages. 33
6. Mean and standard deviations of TSS, TVS and TURB concentrations for all stream gauging stations for analysis Period 3. 34
7. Mean and standard deviations of NH3, TKN, N23, PTL and DSP concentrations for all stream gauging stations for analysis Period 3. 37
8. Mean and standard deviations of COD, TEMP, pH, DOXY and COND for all stream gauging stations for analysis Period 3. 42
9. Mean and standard deviations of TSS, TVS, TURB, TKN, PTL and COD concentrations for all field sites for analysis Period 3. 45
10. Location, physical description and morphometry of Highland Silver Lake, Madison County, Illinois. 47
11. Mean surface water TSS at nine sites in Highland Silver Lake, May 1981-April 1982. 54
12. Mean surface water TVS at nine sites in Highland Silver, May 1981-April 1982. 55
13. Mean surface water TURB at nine sites in Highland Silver Lake, May 1981-April 1982. 59
14. Mean TURB in Highland Silver Lake, by period May 1981-April 1982.

Page

15. Mean surface water N32 concentrations at nine sites in Highland Silver, May 1981-April 1982. 63

16. Mean N32 by period in Highland Silver Lake, May 1981-April 1982. 63

17. Mean surface water TKN concentrations at nine sites in Highland Silver Lake, May 1981-April 1982. 65

18. Mean surface NH3 concentrations at nine sites in Highland Silver Lake May 1811-April 1982. 68

19. Mean surface water PTL concentrations at nine sites in Highland Silver Lake, May 1981-April 1982. 70

20. Mean surface water COD concentrations at nine sites in Highland Silver Lake, May 1981-April 1982. 73

21. Fecal coliform in water samples taken from Highland Silver Lake, May 1981-April 1982. 74

22. A comparison of period variation in chlorophyll content in water samples taken from Highland Silver Lake, May-December, 1981. 75

23. Mean surface water pH at nine sites in Highland Silver Lake, May 1981-1982. 81

24. Mean surface water total alkalinity at nine sites in Highland Silver Lake, May 1981-April 1982. 84

25. Mean surface water COND at nine sites in Highland Silver Lake, May 1981-April 1982. 86

26. Trophic State Index (TSI) values calculated according to Carlson (1977) for Highland Silver Lake, May 1981-1982. 90

27. Mean surface water TSI chlorophyll values at nine sites in Highland Silver Lake, May 1981-April 1982. 90

28. Comparison of mean constituent concentrations in Highland Silver Lake with means obtained for 63 Illinois lakes sampled in 1979. 92

List of Figures

Figure		Page
1	Highland Silver Lake Watershed	7
2	Location of water quality gauging stations within the Highland Silver Lake Watershed.	11
3	Location of field site monitoring stations within the Highland Silver Lake Watershed.	12
4	Map of Field Site 1.	15
5	Map of Field Site 2.	16
6	Map of Field Site 4.	17
7	Map of Field Site 5.	18
8	Map of Field Site 6.	19
9	Map of Field Site 7.	20
10	Location of precipitation monitoring stations within the Highland Silver Lake Watershed.	22
11	Location of biological monitoring stations within the Highland Silver Lake Watershed.	26
12	Location of lake sampling sites on Highland Silver Lake.	28
13	Ranking of 87 lakes by average Secchi transparency (inches), Illinois EPA Volunteer Lake Monitoring Program, 1981.	50
14	Mean monthly turbidity (NTU's) at the Highland Water Treatment Plant.	52
15	Seasonal variation in TSS and TVS at nine sites in Highland Silver Lake, May 1981-April 1982.	56
16	Relationship of Secchi transparency with log turbidity at nine sites in Highland Silver Lake, May 1981-April 1982.	60
17	Relationship of Total Kjeldahl nitrogen to chemical oxygen demand at nine sites in Highland Silver Lake, May 1981-April 1982.	66
18	Relationship of total Kjeldahl nitrogen to total phosphorus at nine sites in Highland Silver Lake, May 1981-April 1982.	71

19 Relationship of total phosphorus to turbidity at nine sites in Highland Silver Lake, May 1981-April 1982. 72

20 Seasonal variation in chlorophyll *a* concentrations at nine sites in Highland Silver Lake, May 1981-April 1982. 77

21 Seasonal variation in dissolved oxygen profile at site 1 Highland Silver Lake, May 1981-April 1982. 79

22 Relationship of Secchi transparency with pH at nine sites in Highland Silver Lake, May 1981-April 1982. 82

List of Abbreviations and Symbols

USEPA = United States Environmental Protection Agency
SWCD = Soil and Water Conservation District
ASCS = Agricultural Stabilization and Conservation Service
SCS = Soil Conservation Service
RCWP = Rural Clean Water Program
ACP = Agricultural Conservation Program
MIP = Model Implementation Program
IEPA = Illinois Environmental Protection Agency
PCB = Polychlorinated Biphenyls
ISWS = Illinois State Water Survey
"STORET" = Storage and Retrieval System
CES = Illinois Cooperative Extension Service
RMS = Resource Management System
NPS = Nonpoint Source
T = Maximum Allowable Soil Loss Tolerance Per Acre
USLE = Universal Soil Loss Equation
C = Corn
Sb = Soybean
Gr = Wheat
in = Inches
mm = Millimeters
FC = Fecal Coliform
FS = Fecal Streptococcus
Ca = Calcium
Mg = Magnesium
Na = Sodium
TSS = Total Suspended Solids
TVS = Total Volatile Solids
NVS = Non-volatile Solids
IPCB = Illinois Pollution Control Board
P = Period
NAS-NAE = National Academy of Science -- National Academy of Engineering
mg/l = Milligrams Per Liter
NTU's = Nephelometric Turbidity Units
^{o}C = Degrees Centigrade
ms/cm = Microsiemens Per Centimeter
TKN = Total Kjeldahl Nitrogen
COD = Chemical Oxygen Demand
BOD = Biological Oxygen Demand
NH$_3$ = Ammonia
N32 = Nitrate & Nitrite Nitrogen
PTL = Total Phosphorous
DSP = Dissolved Phosphorous
KTL = Total Potassium
TEM = Temperature
CFS = Cubic Feet Per Second

Period 1
(P1) = April - June

Period 2
(P2) = July - November

Period 3
(P3) = December - March

Preface

This report is a product of the Comprehensive Monitoring and Evaluation Program for Highland Silver Lake Watershed. This program is one of five in the nation designed to evaluate the effectiveness of the U.S. Department of Agriculture (USDA) Rural Clean Water Program in (a) achieving improved water quality in an approved project area in the most cost-effective manner possible in keeping with the provision of adequate supplies of food, fiber and a quality environment, and (b) assisting agricultural landowners and operators to reduce agricultural non-point source water pollutants and to improve water quality in rural areas to meet water quality standards or goals.

Funding for the Rural Clean Water Program and Comprehensive Monitoring and Evaluation Program is provided by the USDA Agricultural Stabilization and Conservation Service. The U.S. Environmental Protection Agency is assisting USDA in evaluating the effectiveness of the Rural Clean Water Program in improving water quality. The USDA Soil Conservation Service, which provides technical assistance in the Rural Clean Water Program, is also responsible for oversight of the Comprehensive Monitoring and Evaluation Program. The University of Illinois Cooperative Extension Service provides education/information assistance in both programs.

Agencies participating in the Comprehensive Monitoring and Evaluation Program include: the Illinois Environmental Protection Agency, which is responsible for water quality monitoring and evaluation; the Illinois State Water Survey, responsible for water quantity monitoring and evaluation; the USDA Economic Research Service, responsible for the socio-economic evaluation of the project with assistance provided by the University of Illinois -- Department of Agricultural Economics, on the on-farm economic analysis; and the Southwestern Illinois Metropolitan and Regional Planning Commission, on the off-site economic analysis. The Commission is also responsible for coordination of the Comprehensive Monitoring and Evaluation Program. The University of Illinois Agricultural Experiment Station and the Illinois Department of Conservation are providing voluntary assistance on various aspects of the program.

The Illinois State Rural Clean Water Coordinating Committee is providing oversight for the Highland Silver Lake Watershed Rural Clean Water Program and assisting USDA and EPA in their comprehensive, joint water quality monitoring and evaluation, including coordination with the Local Coordinating Committee. Membership of the Illinois State Coordinating Committee consists of the following:

Illinois State ASC Committee
Farmers Home Administration
Cooperative Extensive Service
U.S. Forest Service

Soil Conservation Service
U.S. Environmental Protection Agency -- Region V
Illinois Environmental Protection Agency
Illinois Department of Agriculture, Division of Natural Resources
Illinois State Water Survey
Illinois Department of Conservation
Economic Research Service

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The information presented in this report represents the coordinated efforts of numerous individuals from various agencies and organizations. The assistance of Lee Rogers (ASCS), Jim Krejci (CES), Wayne Kinney and Dana Walker (SCS) is greatly appreciated. The contributions of Kent Mitchell and Dale Vanderholm are gratefully acknowledged. The Highland Water Treatment Plant operators assisted in data collection. Project equipment has been installed or stored on the land of the following owners: City of Highland, Clarence Klaus, Kevin Firsse, Milton Winet, George Beck, Walter Steiner, Randy Beck, Elmer Klenke and Elmer Kraus.

The Illinois State Water Survey (ISWS) has contributed significantly to this project. ISWS was contracted to perform components of this project. ISWS's activities are being carried out under the direction of Dr. Ming Lee, P.E.

Mark Grinter administered the field sampling program within the watershed. He was responsible for collection and transportation of all field samples and for the installation and continual maintenance of all field sampling equipment. He also assisted in most lake sampling and in all biological collecting. Jack Adams of the IEPA-Collinsville Office helped transport samples to the Marion laboratory. Many individuals of the IEPA Monitoring Unit, under the direction of Kenneth Rogers, assisted in various aspects of the monitoring program.

Analysis for perishable and non-metallic chemical constituents in water samples were performed at IEPA-laboratory in Champaign, under the direction of Roy Frazier. Analyses of Kjeldahl Nitrogen and designated metals in water samples were also performed at the Champaign laboratory. The IEPA-Springfield laboratory, under the direction of John Hurley, performed organic pesticide and PCB analysis of water samples.

The analysis of water samples for total and volatile solids and fecal coliforms and the filtration of chlorophyll samples was accomplished at the IEPA-Marion laboratory, under the direction of John Craig. Chlorophyll analysis was performed at the IEPA-Chicago laboratory, under the direction of John Murray.

Cora Stockton, John Little, Jill Hardin, Mary Anderson, Donna Sefton and Douglas Crandall assisted in data analysis and report preparation. The coordination, guidance and editorial comments of Kenneth Rogers, Robert L. Hite and Robert Clarke were greatly appreciated. Gloria Ferguson created the report cover and assisted with the graphics. This report was typed by the Word Processing Unit, under the direction of Norma Kraus, and was printed in the Print Shop, under the direction of Claude Pearson. Nancy Simpson and Sue Carlson provided library assistance. Karen Janssen assisted in report preparation.

Executive Summary

I. Background: The Illinois Environmental Protection Agency (IEPA) in cooperation with various State and Federal agencies is evaluating the impact of Resource Management Systems (RMS's) implemented under the Rural Clean Water Program in the Highland Silver Lake Watershed; Madison County, Illinois. The primary objective of this comprehensive monitoring and evaluation project is to document the effectiveness of land treatment programs in terms of water quality/quantity impacts.

II. Investigation: The physical, biological and chemical characteristics of the Highland Silver Lake Watershed were studied since December 1981. A comprehensive monitoring network for the entire Highland Silver Lake Watershed was established by IEPA with the cooperation of ISWS, to document the basic hydrological, meterological, and water quality factors of the project area during 1981-1982. The duration, timing and quantity of non-point source pollutants were evaluated to determine land management effects on the water quality/quantity budget. Field and laboratory procedures are those accepted for agricultural related hydrology research. Analytical techniques are documented, but not detailed.

III. Results: Three periods based on the amount of surface cover and land management activities, were selected for evaluating seasonal variation in streamflow and constituent concentrations. These periods are: P1-fertilizer and seedbed establishment period (April-June); P2-reproduction and maturation period (July-November); and P3-residue (December-March).

A. Watershed: In this report, analysis covers only the P3 measurement period. Due to the low number of observations no preliminary trend analysis was attempted.

B. Field Sites: This analysis covers the P3 measurement period. Due to the low number of observations no preliminary trend analysis was attempted.

C. Lake: The condition of the lake was evaluated in three ways: 1) through IEPA's Volunteer Lake Monitoring Program, 2) Turbidity at the Highland Water Treatment Plant and 3) Lake Quality.

1) Volunteer Lake Monitoring: Mean Secchi disc transparency was 13.8 inches placing Highland Silver Lake 73rd in a ranking of 87 Illinois lakes from most to least transparent.

2) Turbidity at the Water Treatment Plant: Mean monthly turbidity values in water taken from Highland Silver Lake since 1976 have been decreasing. There were definite seasonal trends; these result from the normal precipitation and land management activity patterns for the watershed. Higher turbidity values occur during the spring and lower values are measured in late summer and early fall.

3) Lake Water Quality: This report summarizes water quality data for Highland Silver Lake obtained on nine sampling dates between May 1981 through April 1982. On each sampling date water samples were collected one foot below the surface at nine sampling sites; bottom water samples were also collected at the site nearest the dam (Site 1). Temperature and dissolved oxygen measurements were made at each site from the surface to the bottom at two feet intervals.

   a. Temperature and dissolved oxygen profiles: Temperature data revealed evidence of thermal stratification from late May through early September at the dam end of the lake. Concomittant with the establishment of thermal stratification was the depletion of oxygen in the hypolimion leading to existence of anaerobic conditions through the summer stratification period. Complete oxygen depletion in bottom water was only noted at Site 1.

   b. Turbidity and suspended solids: Water clarity was assessed in the field by Secchi transparency and analytically by turbidity and total and dissolved solids. Preliminary data indicated that Highland Silver Lake is one of the most turbid lakes in the State with visability rarely exceeding 11.5 inches, the bulk of turbidity was due to non-volatile suspended solids and the greatest decrease in transparency (i.e., increase in turbidity) occurred in spring. The greatest transparency observed occurred during late fall and winter.

   c. Nutrients: Water samples were filtered in the field for determination of total and dissolved phosphorus. Nitrogen determinations were made for nitrate plus nitrite, ammonia and total Kjeldahl nitrogen.

      i. Phosphorus -- total and dissolved phosphorus concentrations were relatively high and showed similar spatiotemporal variation. Total phosphorus was significantly positively correlated with total suspended solids.

ii. Nitrogen -- highest concentrations of nitrate+nitrite nitrogen, ammonia and total Kjeldahl nitrogen occurred in Period 1 (i.e., fertilization and seedbed establishment). Ammonia concentrations were especially high and may have been attributable to fertilize application.

d. Fecal Coliform: In general, Illinois lakes appear relatively free from fecal contamination; Highland Silver Lake may be an exception since more than twenty percent of the samples contained greater than 200/100 ml.

e. Trophic State: Preliminary monitoring conducted during the period May 1981 -- April 1982 indicate that Highland Silver Lake can be described as highly turbid and well supplied with nutrients. Although chlorophyll a data suggests a low algal standing crop, Highland Silver Lake by most standards would be considered hypereutrophic. The low algal biomass is most likely attributable to light limitation.

PERSPECTIVE

Half of the land in the nation is in agricultural or related uses. Agriculture is the most widespread cause of nonpoint source pollution. Initial "208" water quality planning efforts demonstrated that agricultural activities are a significant source of pollution in many parts of the country. The resources required to control agricultural nonpoint 'source' problems will be substantial. Both public and private investment must be utilized in the most cost-effective manner for that purpose.

Nonpoint Source (NPS) pollution prevents the optimal use of the water resources. This pollution can originate from runoff of agricultural land or from groundwater return flow draining agricultural land. Surface runoff from agricultural land transports nutrients, pesticides, disease causing organisms and organic and inorganic-particulate material to water resources. Groundwater return flows can cause nutrient, pesticide and dissolved solids pollution problems. Eroded sediment is the most significant pollutant in terms of damage caused and total load carried by a stream (Stewart, 1975).

Efficient Resource Management Systems (RMS) must be installed to control these problems. A comparison of low and high-cost RMS's effectiveness in terms of water quality impacts must be made, so that the RMS implemented will be problem solving specific. The RMS's implemented in the Highland Silver Lake Watershed are designed to be site and problem specific; thus the degree of effectiveness will vary when implemented under different climatic and geomorphological conditions. An attempt must be made to determine the effectiveness of RMS's at other locations, to enable the land owner/operator to implement the most reasonable RMS(s) for their area and problem(s).

Evalution of NPS control projects is an integral component of the future implementation phase of NPS control programs (MIP, RCWP and ACP Special Projects). Watershed evaluation programs must provide guidance to be of use for inputs to many administrative functions, such as: 1) investment of funds, 2) justification for allocation of these funds, 3) verification of overall program effectiveness, 4) evaluation of regional effectiveness of RMS's, and 5) informing local land owner operators as to the effectiveness of their efforts to improve water quality (Hall and Shuyler, undated). The Highland Silver Lake Watershed project will help provide this guidance.

The Highland Silver Lake Watershed monitoring and evaluation project is short-term due to availability of funds. Large incremental changes in the overall lake water quality, due to the RMS's implemented, will probably not be measurable within the 3 1/2 year monitoring period because of the high degree of inherent variability within the system and the long response time of natural ecosystems to such subtle changes. Report of findings will be produced for each component and phase of the project.

INTRODUCTION

The Illinois Environmental Protection Agency (IEPA) in cooperation with Illinois State Water Survey, is monitoring the water quality/quantity impacts of Resource Management Systems (RMS's) implemented under the Rural Clean Water Program in the Highland Silver Lake Watershed, Madison County, Illinois. The primary objective of this project is to document the effectiveness of land treatment program in terms of water quality/quantity impacts. The purpose of this report is to present the water quality data collected from project inception thru March 31, 1982 as part of the Highland Silver Lake Watershed Project.

DESCRIPTION OF HIGHLAND SILVER LAKE WATERSHED

The Highland Silver Lake Watershed encompasses 30,946 acres in eastern portion of Madison County, Illinois. It drains into Highland Silver Lake through Silver Creek and numerous tributaries (refer to Figure 1). The Highland Silver Lake Watershed is located approximately one mile northwest of Highland, Illinois.

Highland Silver Lake, an artificial impoundment, was constructed in 1962 by the City of Highland as a public water supply. It is also utilized for recreation and flood control. There is one known municipal discharge the Highland Silver Lake Watershed, Grantfork Elementary Center, upstream from Highland Silver Lake.

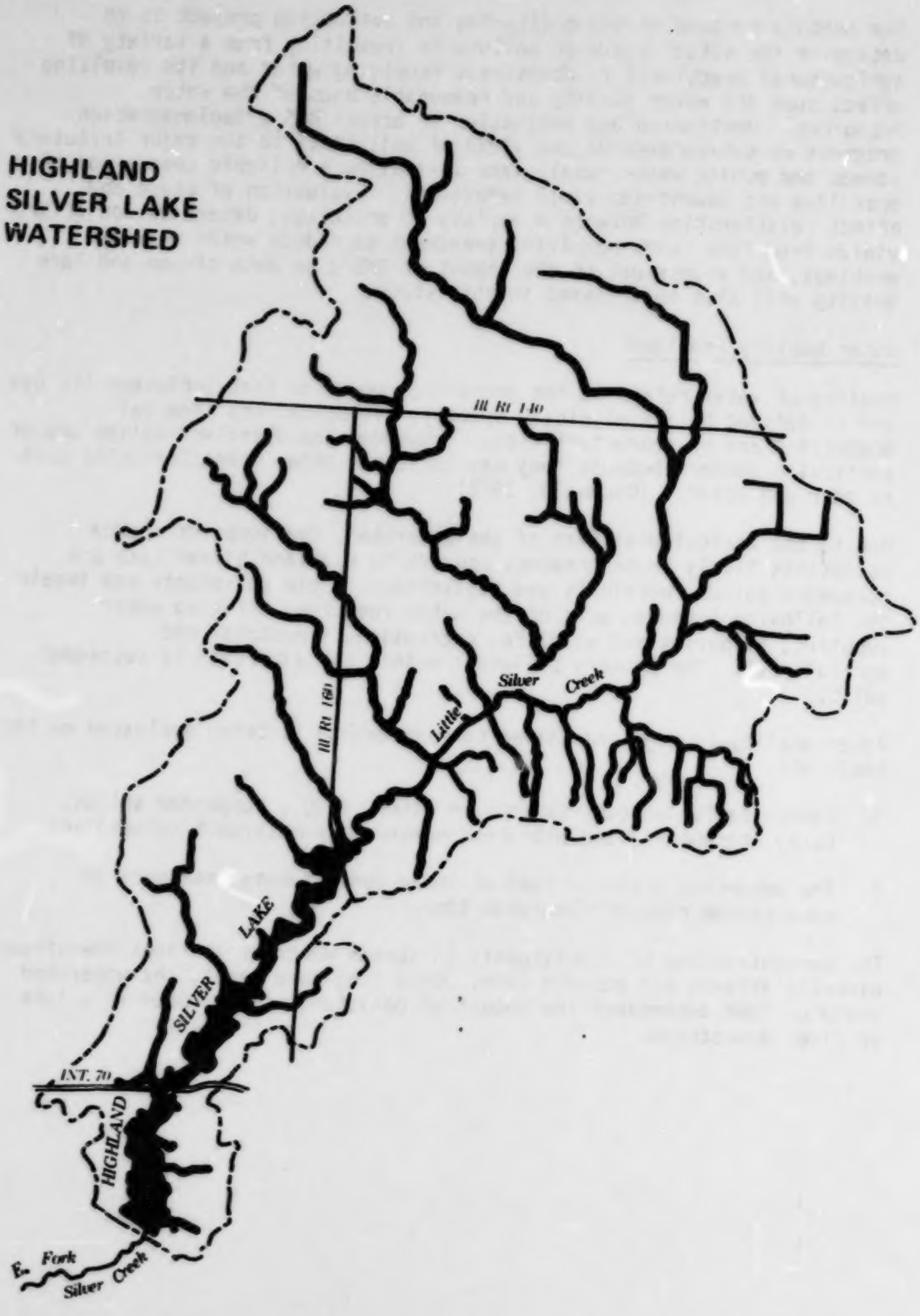
Agriculture is the predominant land use in the watershed with 88% of the land devoted to row crops (Table 2). Major crops grown in the watershed include corn (8,570 acres), soybeans (12,350 acres) and wheat (4,285 acres). Pasture land comprises an estimated 5% of the watershed (1,662 acres). The principal crop rotations are: corn/soybean; corn/soybean/wheat with double crop soybeans; soybean/wheat/with double crop soybeans; corn/soybean/wheat/meadow and corn/corn/soybeans/wheat and 4 years of meadow. About 4% of the watershed is in woodland (1250 acres). Silver Lake and other small water bodies cover about 3% of the watershed (830 acres). The Village of Grantsfork, the only urban area in the watershed comprises about 0.7% of the total acreage (210 acres) (SCC, 1981).

TABLE 1

Land use/cover in the Highland Silver Lake Watershed, 1981, by acres and percent. (W.E. Gates, 1982)

Land Use/ Cover	# of Acres	%
Cropland	25,205	3.3
Past/Hayland	1,662	5.4
Woodlands	1,250	4.1
Urban	210	0.7
Feedlots	116	0.4
Interstate	49	0.2
Wildlife	327	1.1
Farmsteads	619	2.0
Residential	356	1.2
Gravel	15	0.0
Water	830	2.7
Total	30,639	100

HIGHLAND SILVER LAKE WATERSHED


Ill Rt 140
Ill Rt 160
Little Silver Creek
SILVER LAKE
INT. 70
HIGHLAND
E. Fork Silver Creek

PURPOSE OF SPECIAL MONITORING AND EVALUATION

The primary purpose of the monitoring and evaluation project is to determine the actual yield of pollutants (resulting from a variety of agricultural practices) to downstream receiving water and its resulting effect upon the water quality and reasonable uses of the water resources. Monitoring and evaluation of actual RMS's implementation progress on sub-watersheds and yield of pollutants to the major tributary stream and public water supply lake will allow a reliable comparison of practices and downstream yield reductions. Evaluation of cause and effect relationships between a variety of practices, determination of NPS yields from farm lands requiring treatment to reduce water quality problems, and assessment of the impact of RMS's on both stream and lake quality will also be assessed in this study.

Water Quality Problems

Quality of water refers to the properties of water that influence its use and is defined by its physical, optical, biological and chemical properties and of characteristics. Suspended and dissolved solids are of particular concern because they may influence other characteristics such as odor and color. (Oschwald, 1972).

Due to the agricultural base of the watershed, the nonpoint source pollutants likely to be greatest concern in Highland Silver Lake are suspended solids, nutrients and pesticides. These pollutants can impair the following intended uses of the water resource; drinking water supplies, fisheries and wildlife, recreation, industrial and agricultural. The primary pollutant within the watershed is suspended solid.

Water quality in Highland Silver Lake watershed is being evaluated on the basis of:

1. Concentration of constituents in water, (e.g., suspended solids, total phosphorus, and nitrates, measured in mass/unit volume) and
2. The watershed yield or load of these constituents, measured in mass/volume rate of flow/unit time.

The concentrations of constituents in stream water as it flows downstream directly affects all aquatic life. On a long-term basis, the watershed yield or load determines the amount of pollutants contributed to a lake or river downstream.

Water Quality Improvement Goals

The goal of the RCWP land treatment project is to reduce suspended solids within the water column. The 1984 goal is 1) reduce turbidity and increase visibility to greater than 2 feet, and 2) reduce total suspended solids concentration to an average of less than 25 mg/l. The long-term goal is to maintain average total suspended solids concentrations of 10-15 mg/l (SCC, 1981).

MONITORING STRATEGY

The comprehensive monitoring network for the entire Highland Silver Lake watershed was established by IEPA and ISWS to document the basic hydrological, meterological and water quality factors of the project area (Figures 2 and 3). The duration, timing and quantity of NPS pollutants will be evaluated to determine land management effects on the water quality/quantity budget. The main stem of Silver Creek is monitored at two locations (Stations GS-1 and GS-2) representing 50 and 70% of the drainage area respectively. Thus, spatial patterns, land use and physiographic characteristics can be evaluated relative to their actual and projected impacts on downstream water quality and lake characteristics.

Seven fields ranging in size from 40 to 350 acres are being monitored concurrent with the major tributary monitoring. These areas are natural drainage networks. The areas were selected to provide comparative information on field level conditions representative of the physiography and land use activities impacting on water quality and uses.

Feedlot discharge into water-courses is a major water pollution problem in Illinois. Holding ponds and watering equipment with vegetative filter treatment and infiltration areas were recommended to replace the zero-discharge treatment systems. The vegetative filter system may include pasture, grass waterways, or terrace channel (Dickey, 1981). The vegetative-filter approach uses broad overland flow or graded terrace systems and combines infiltration, dilution, and filtration to produce an effluent suitable for discharge. Field site 8 was established to monitor the outflow of a vegetative filter strip.

Streamflow at the tributary stations is measured on a daily basis. Runoff from rainfall and snowmelt is intensively sampled during the entire event because most of the sediment transported by streamflow is carried during a few large storms. During a runoff event, the sediment concentration usually changes abruptly and increases with increased discharge. The frequency and timing of the intensive water quality sampling program is keyed to storm events.

There are three biological monitoring stations in the watershed. Biological monitoring consists of collecting macroinvertebrates within a given area. These organisms are used as indicators of water quality.

Organisms will be assigned a tolerance status in accordance with IEPA's Species Tolerance List (currently being revised). Each biological monitoring station will be classified as balanced, semi-polluted or polluted, based upon the abundance of intolerance organisms. The tolerance and stream classification are included in the Appendix Section.

The lake is monitored at nine locations to determine water quality and subsequent impacts of RMS's implementation (Figure 4).

Description of Monitoring Stations

Descriptions of the individual watershed monitoring stations are presented below. Refer to Figures 2 and 3 for the location of the monitoring stations.

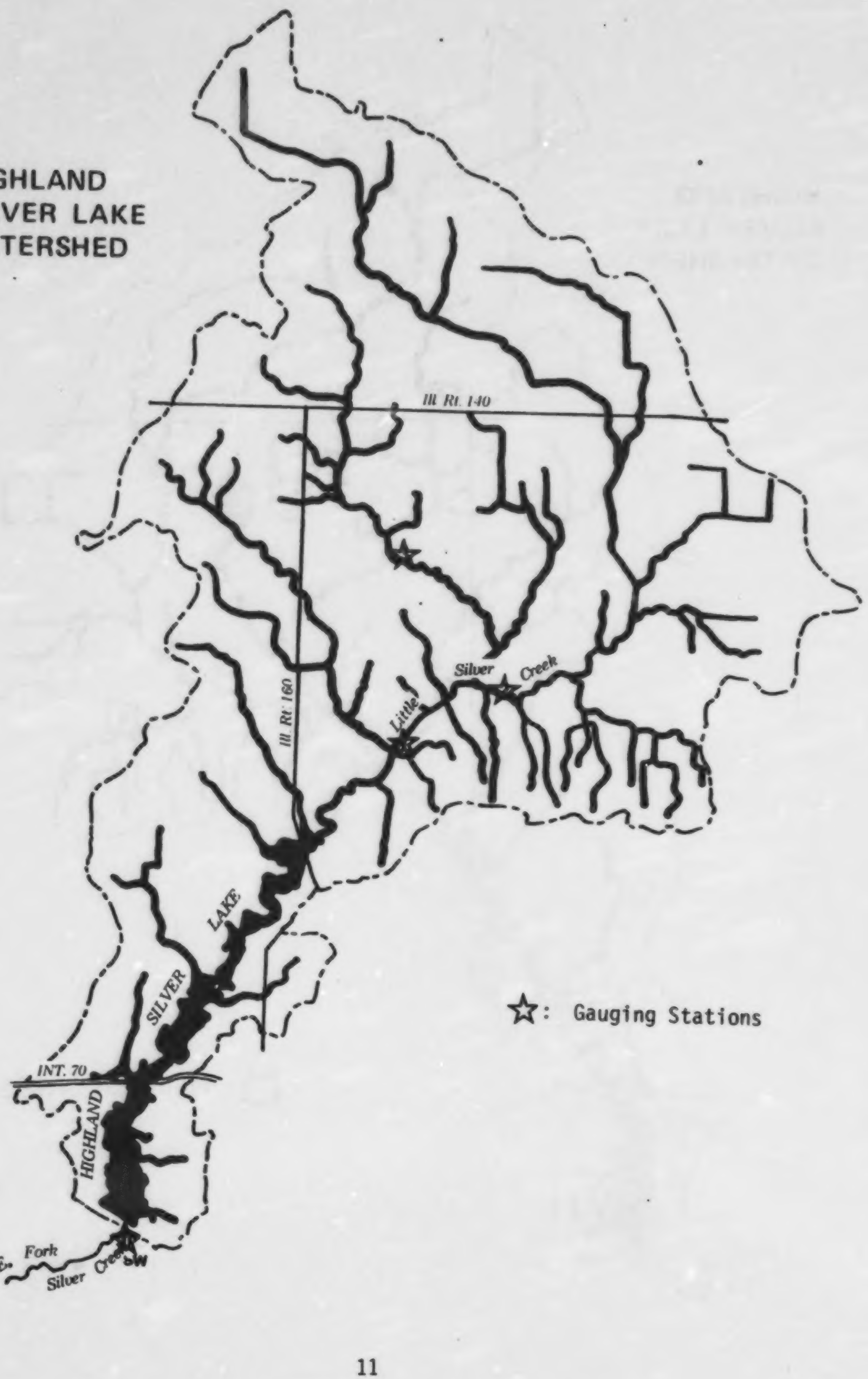
Tributary Stations

Station SW, the spillway, samples possible outflow of the lake. Spillway samples are taken on the lake side of the dam. The drainage area is 30,639 acres including the lake.

Three tributary monitoring stations have been established (GS-1, GS-2, and GS-3) within the watershed. Stations GS-1 and GS-3 are located on East Fork of Silver Creek and have drainage areas of 24,858 and 3,319 acres, respectively. GS-2 is located on Little Silver Creek and has a drainage area of approximately 18,000 acres.

Field Site Monitoring Stations

Eight field site monitoring stations have been established within the Highland Silver Lake Watershed.


Ill Rt. 140
Ill Rt. 160
Little
Silver Creek
LAKE
SILVER
INT. 70
HIGHLAND
E. Fork
Silver Creek
SW
☆: Gauging Stations

HIGHLAND
SILVER LAKE
WATERSHED

HIGHLAND SILVER LAKE WATERSHED

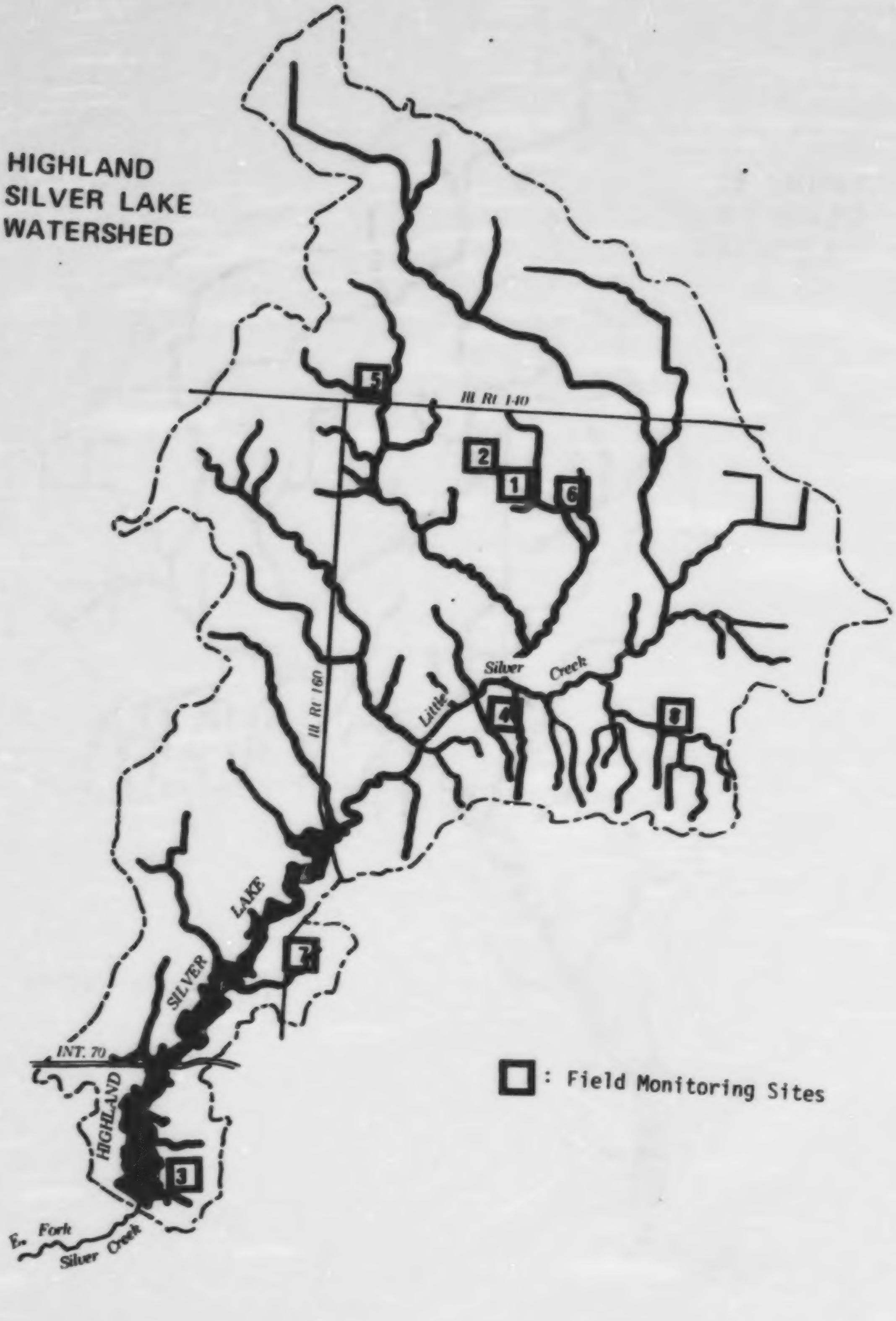

5
Ill Rt 140
2
1
6
Ill Rt 160
Little
Silver
Creek
4
8
LAKE
SILVER
7
INT. 70
HIGHLAND
3
E. Fork
Silver Creek
☐ : Field Monitoring Sites

TABLE 2

Outline of sampling protocol for Highland Silver Lake Watershed denoting sampling frequency and parameter coverage.

	SAMPLING FREQUENCY			
	Daily (MWF)	Biweekly	Monthly	Event
Lake Outflow Station	-	TSS, TVS, NTUs PTL, TKN, DSP, N32 NH3	ICAP metals	-
Field Site	-	-	-	TSS, TVS, NTUs, TKN, PTL
Tributary Stations	TSS, TVS, NTUs	TSS, TVS, NTUs PTL, TKN, DSP, N32 NH3	ICAP metals	TSS, TVS, NTUs, TKN, PTL

TSS = total suspended solids, TVS = total volatile solids, NTUs = nephelometric turbidity units, PTL = total phosphorus, TKN = total Kjeldahl nitrogen, DSP = dissolved phosphorus, N32 = Nitrate + Nitrite

TABLE 3

Drainage area, soils and conservation practice for each field monitoring site.

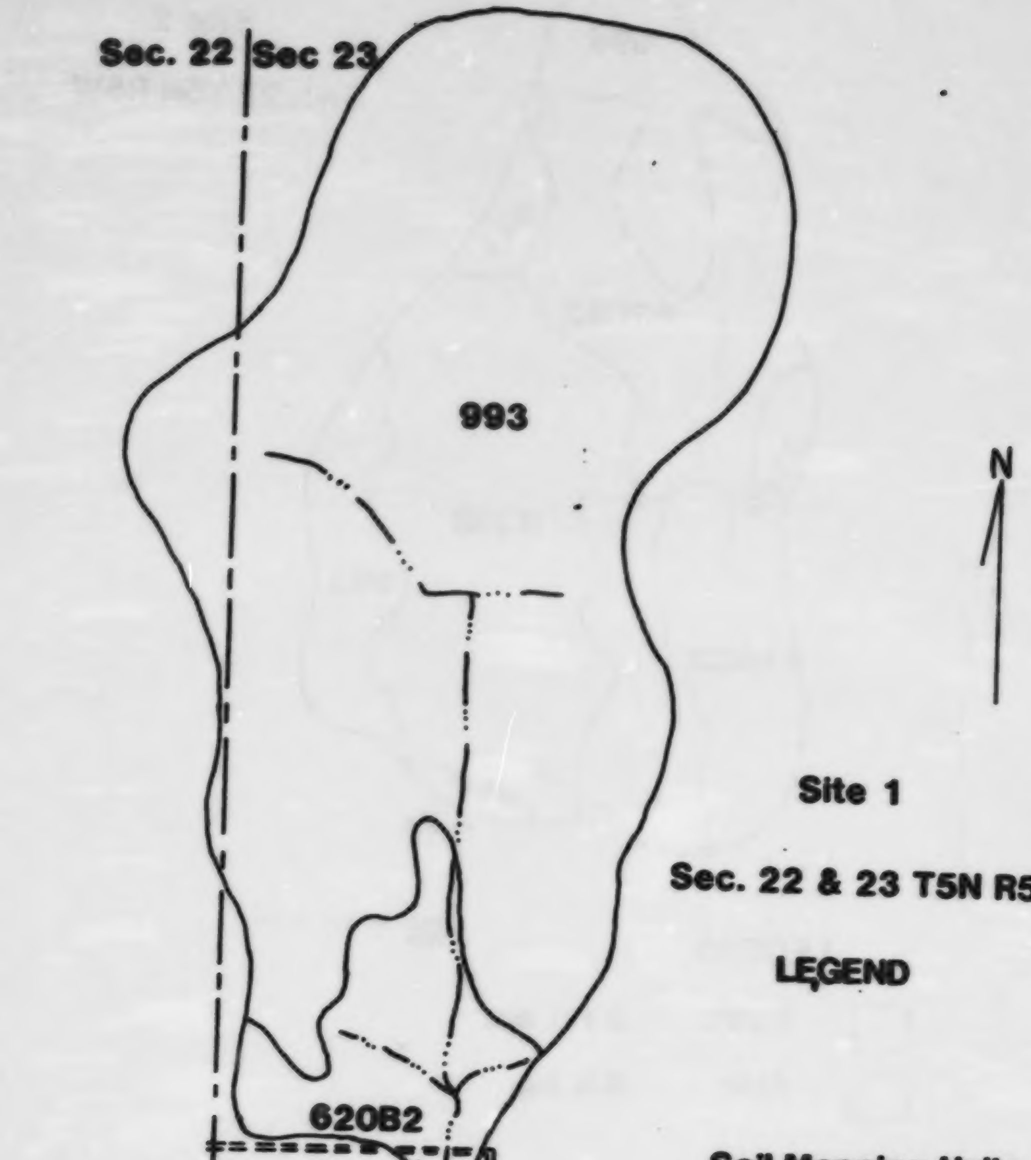
Field Site	Drainage Area (Ac)	Soils	Conservation Practice
1	60	Natric	Reduced tillage
2	45	Natric	No fill; short terraces
3	50	Mollic/Alfic	Reduced tillage; terraces
4	133	Natric	Grass waterway; reduced tillage on the contour
5	368	Natric	None
6	64	Natric	None
7 *	173	Natric/ Alfic/Mollic	Reduced Tillage
8	1.2	Natric	Vegetative Filter Strip

*Lower portion of drainage area is in timber.

Vegetative Filter System Monitoring Station

Field Site 8 is located due west of Station GS-2. Runoff resulting from rainfall events and snowmelt is sampled at Field Site 8. The station was established in June, 1982.

Drainage area consists of 1.23 acres of an animal (beef) feedlot and a vegetative filter system. The concrete feedlot area is 0.46 acres and the vegetative filter system area is 0.77 acres. This vegetative filter was designed according National SCS Standards; Reed canarygrass and tall fescue are to be established. The current livestock operation consists of approximately 200 head of feeder cattle, with planned expansion to 350 head. Manure produced in the feedlot will be scraped and stored in a concrete stacking area designed for temporary storage of solids for a 150 day period. Solids collected in both the settling basin and the stacking area will be utilized on cropland and hayland. On this basis the land available for disposal will handle all waste from approximately 300 animals.


Sec. 22
Sec 23
993
620B2
N
Scale
0
400
800

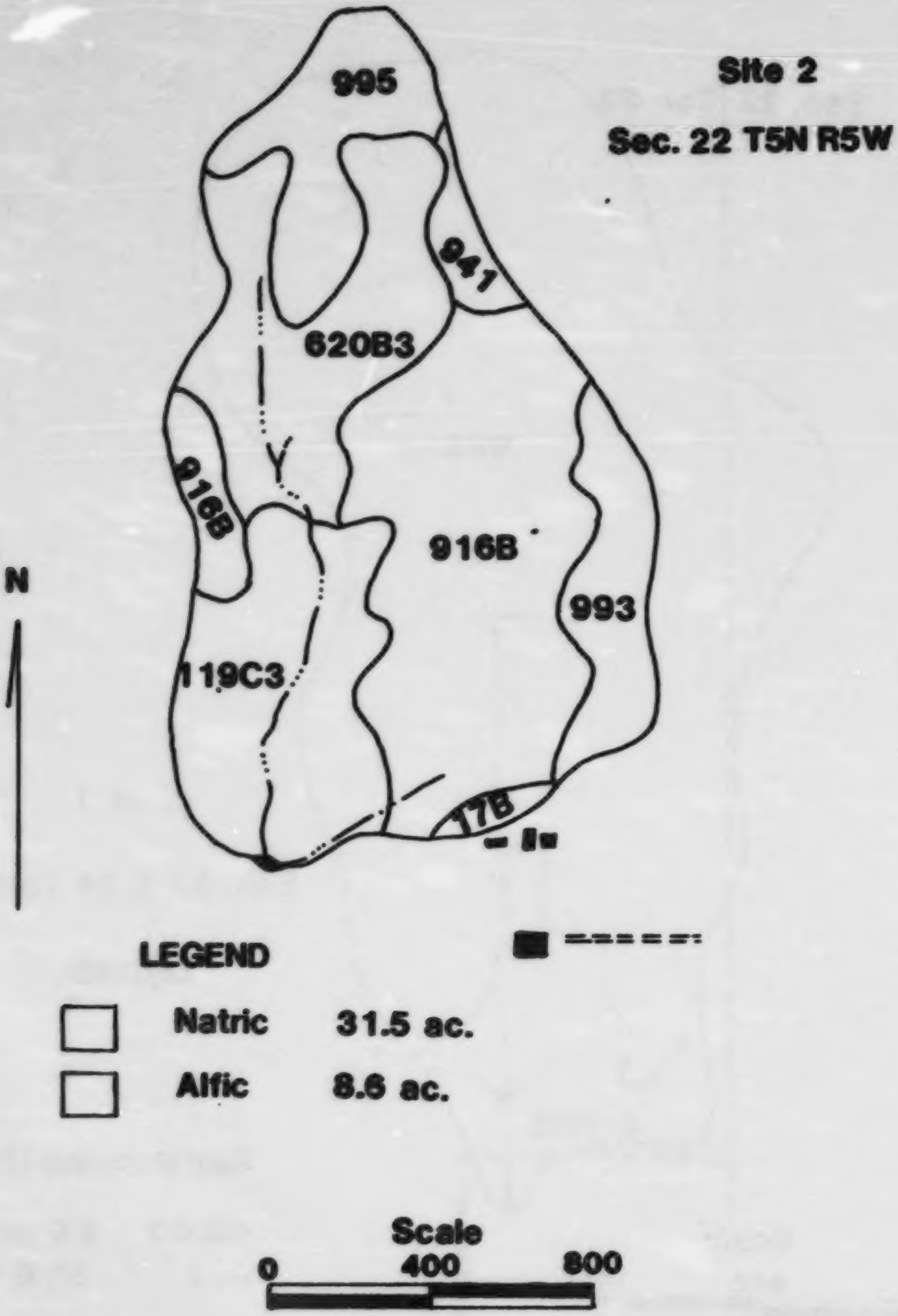
Site 1

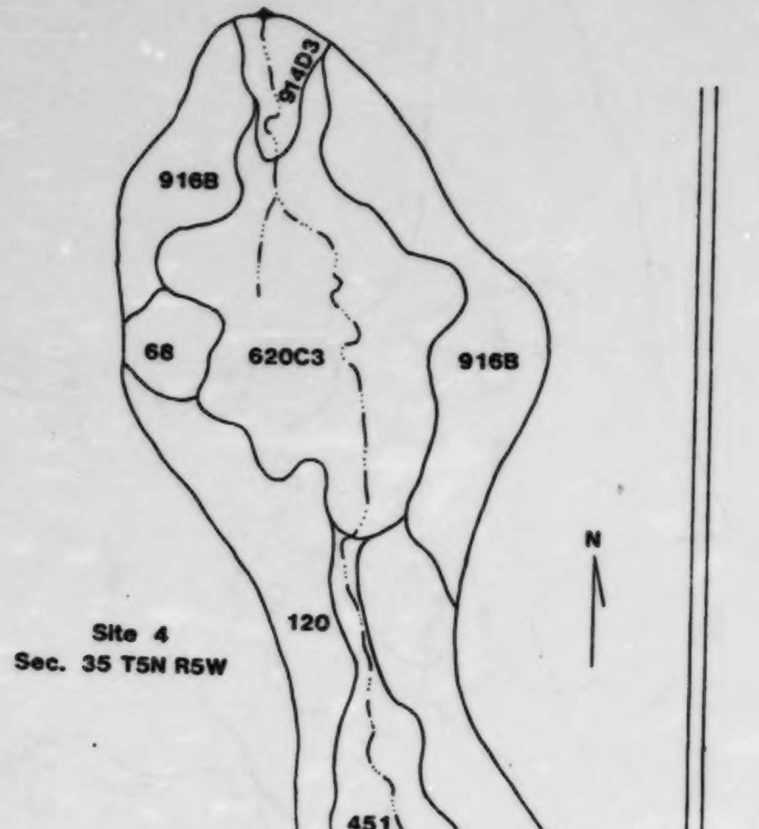
Sec. 22 & 23 T5N R5W

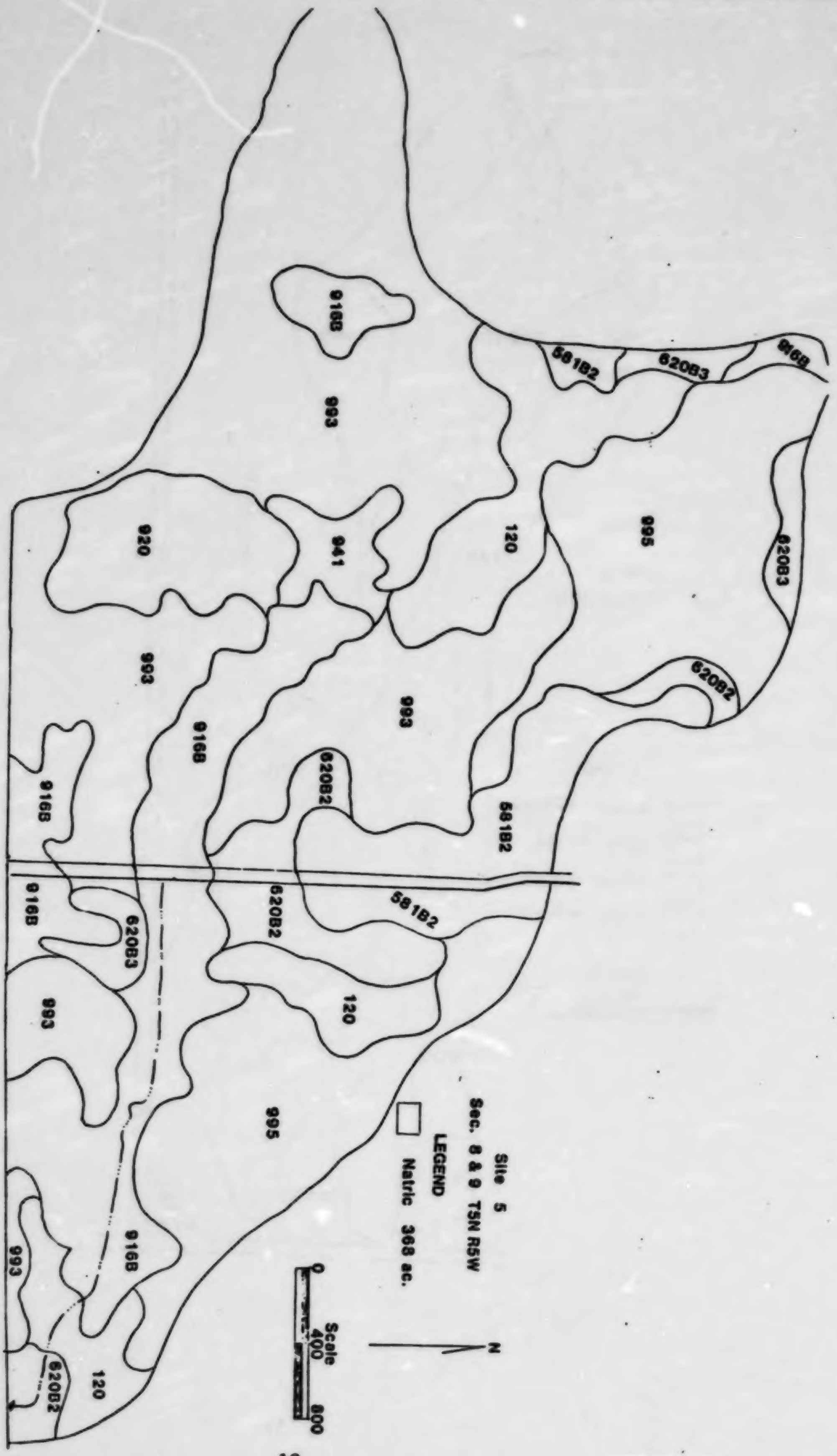
LEGEND

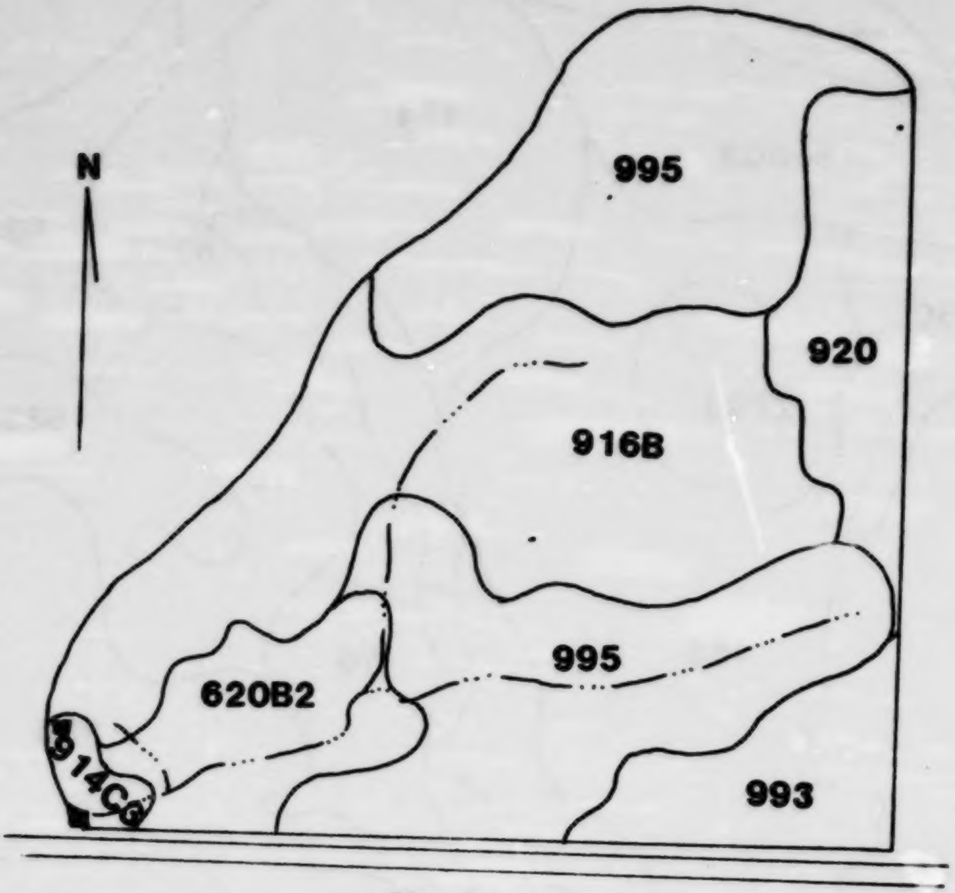
Soil Mapping Units

620B2	6.6 ac.
993	55.6 ac.


Site 2
Sec. 22 T5N R5W
995
941
620B3
916B
916B
993
119C3
17B
N
LEGEND
Natric 31.5 ac.
Alfic 8.6 ac.
Scale
0
400
800


914D3
916B
68
620C3
916B
N
Site 4
Sec. 35 T5N R5W
120
451
W
916B
LEGEND
Natric 119 ac.
Alfic 2.2 ac.
Mollic 3.7 ac.
Entic 8.6 ac.
41B
Scale
0
400
800
620B2
995
916B
581B2
620B2


Site 5
Sec. 8 & 9 T5N R5W
LEGEND
Natric 368 ac.
N
Scale
0
400
800
916B
993
581B2
620B3
916B
120
995
920
941
620B3
993
993
620B2
916B
620B2
916B
581B2
916B
620B2
581B2
620B3
993
120
995
916B
993
620B2
120


N
995
920
916B
995
620B2
914C3
993

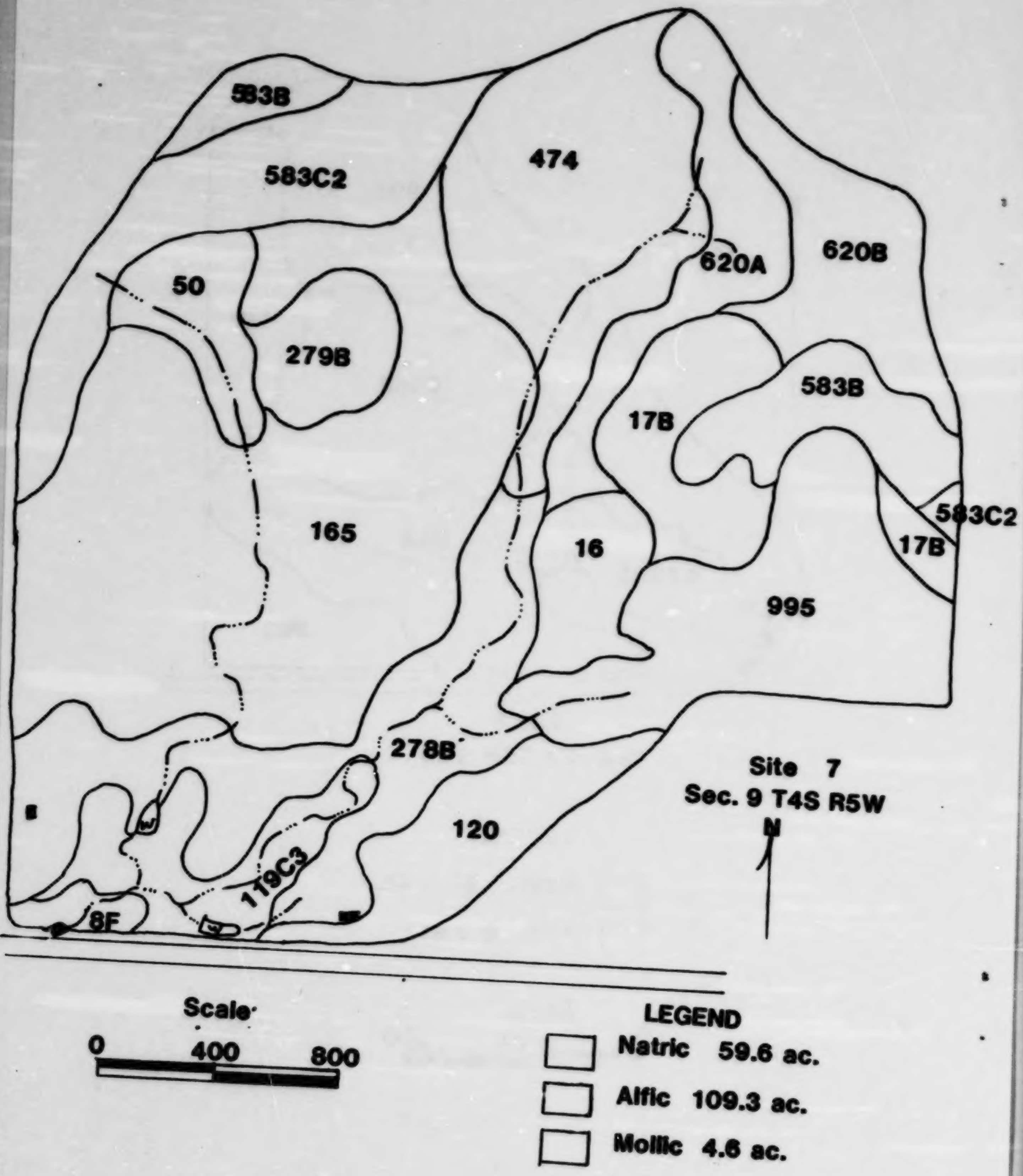
Site 6
Sec. 23 T5N R5W

LEGEND

☐ Natric 62.8 ac.

☐ Alfic 0.9 ac.

Scale
0 400 800


583B
583C2
474
620A
620B
50
279B
583B
17B
165
16
583C2
17B
995
278B
120
119C3
8F
Site 7
Sec. 9 T4S R5W
N
Scale
0
400
800
LEGEND
Natric 59.6 ac.
Alfic 109.3 ac.
Mollic 4.6 ac.

MONITORING METHODS

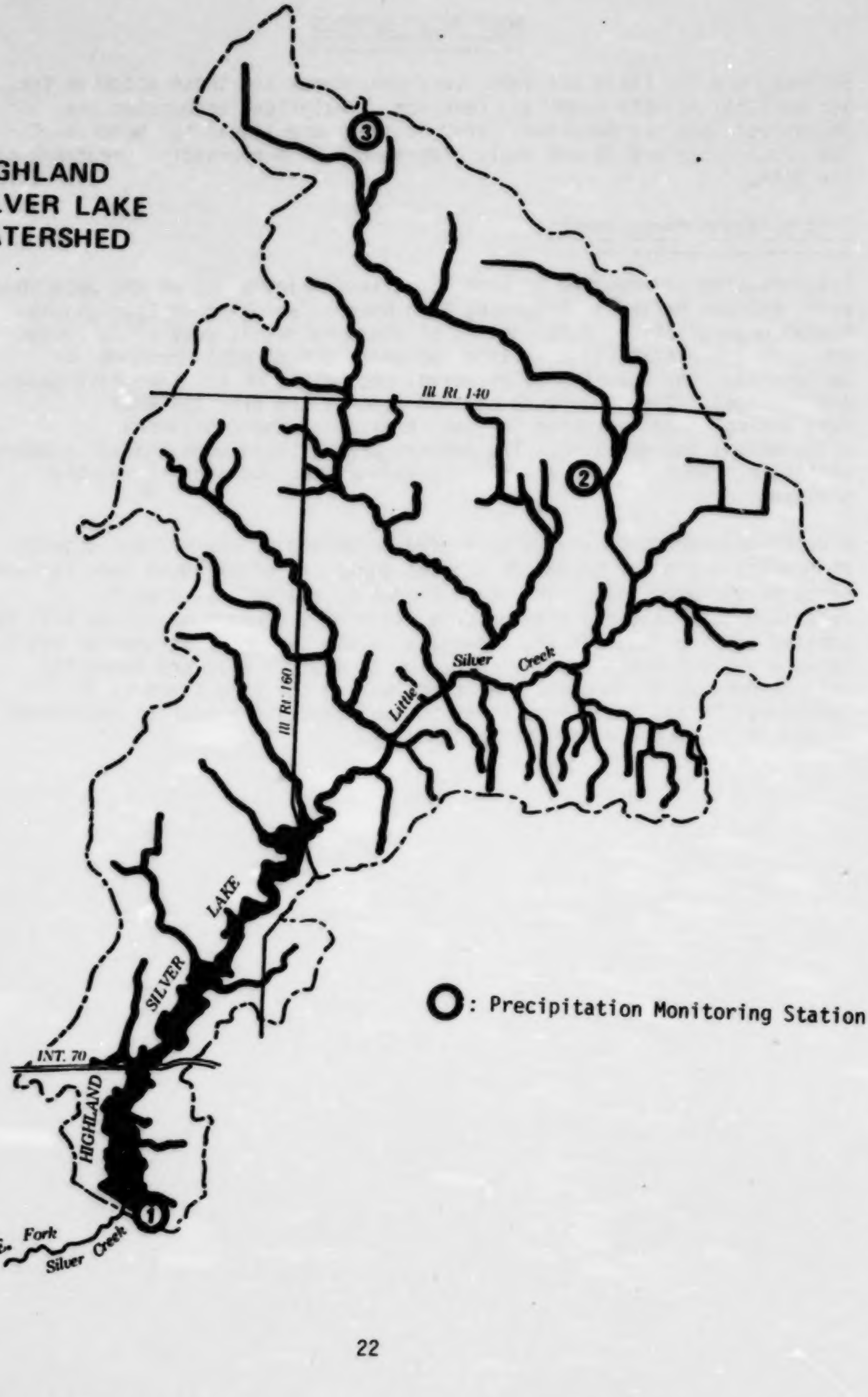
Methods used for field and laboratory procedures are those accepted for agricultural related hydrology research. Analytical techniques are documented, but not detailed. Product names are listed for benefit of the reader only and do not imply endorsement or preferential treatment by the IEPA.

Precipitation Measurements

Precipitation is measured at three locations (Figure 10) on the watershed using Belfort Universal Recording Rain Gauges (weighing -- type gauge). Annual precipitation, total amount of storm rainfall, rate of delivery, duration and distribution in time and space are directly measured or calculated. For annual precipitation, the values of all five rain gauges are averaged. The individual station records are utilized when determining storm variation for soil erosion/sediment delivery calculations and modeling. Two methods are utilized when analyzing storm variation, these methods are depth-area-duration and storm frequency analyses.

A depth-area-duration analysis is used to determine the maximum amounts of precipitation for storms of various durations distributed over various parts of the watershed. The storm frequency analysis is used to determine the frequency with which a storm of a certain magnitude will be equaled or exceeded. It was necessary in the design of structural RMS's to know the frequency with which storms of a given size and intensity will be equaled or exceeded. When evaluating the effectiveness of individual RMS's, the frequency of the measured storm must be determined to see if it exceeded the design capacity.

HIGHLAND SILVER LAKE WATERSHED



3
Ill Rt 140
2
Ill Rt 160
Little Silver Creek
SILVER LAKE
HIGHLAND
INT. 70
1
E. Fork Silver Creek
○: Precipitation Monitoring Station

Flow Measurements

There are eleven automated flow gauging stations installed in the Highland Silver Lake Watershed. The three major streamflow gauging Stations GS-1, GS-2 and GS-3 consist of stilling wells, (diameter; 24 in.) and a Leupold Stevens continuous water level recorder. The stilling well is a corrugated pipe installed to a level below the river bottom and connected to the river flow by underground pipes. The stage in the river is the same as the elevation of the water in the corrugated pipe (stilling well), which is recorded by the Leupold Stevens recorder. The river banks and channel are undisturbed. The remaining seven automatic stations are field runoff gauging stations each have a H-Flume and a watch-dog type Leupold Stevens water level recorder. These instruments continuously record the level (stage) of runoff on a strip chart after being activated. Flumes were needed at these locations to insure the required precision of runoff estimates. A flume is a device for controlling the flow by keeping the water moving for some distance in a constant cross-sectional area. These flumes were designed to minimize the errors in determining the relation of runoff to stage. ISWS designed and installed the flumes; Leupold Stevens' strip charts are digitized by the ISWS for subsequent analysis.

To record maximum streamflow during runoff events crest gauges have been installed at five locations on East Fork Silver Creek and the other major tributaries. The highest water level leaves a mark on the gauge that the field sampler records when collecting stream bed samples for analysis after runoff events. The crest gauge measurements are checked against the Leupold-Stevens water level records for accuracy and profile information for computing streamflow.

Streamflow at Stations GS-1, GS-2 and GS-3 are estimated as a function of stage based on measured discharge using a velocity current meter during time of known stage (Holton et al., 1968). A pygmy current meter is used to measure volocity.

At field stations, flumes are rated H-Flumes; as such, the discharge hydrographs (discharge is plotted over time the resulting curve is a hydrograph) can be estimated directly from published rating curves and recorded stage data. Most stations became operational in February, 1981. Vegetative Filter Monitoring Station became operational in June, 1982.

The overflow of Highland Silver Lake is monitored at the spillway, Station SW. Lake level is recorded daily by water treatment plant personnel. These readings are used in conjunction with the spillway rating curve to estimate lake outflow.

Field methods used in this study are a recognized compromise between the accuracy and precision of field sampling and the funds available for the study. Generally, estimates of streamflow using uncontrolled sections of channel have an accuracy of about ± 10%. When flood events occur which are significantly greater than any measured streamflow, the accuracy of estimation of peak flow is unknown. As flow durations of extreme flood events are short, the overall accuracy of a water balance is much better than prediction of short-term peak flows.

Watershed Water Quality Sampling

Water quality monitoring was initiated in December, 1981. Twelve ISCO automatic water samplers (model 1680) sample streamflow during runoff events. The ISCO samplers were located at gauging Stations GS-1 and GS-3. At stations GS-1 and GS-2, the samplers were programed to collect 250 millimeters (ml) of streamflow each 7 1/2 minutes compositing two samples per bottle. Each sampler would collect 7 1/2 minute samples for a 7-hour period once started. At the field sites the samplers were programed to collect 250 ml of streamflow, compositing two samples per bottle. Each sampler would collect samples at different time intervals depending upon the surface cover and antecedent precipitation once started.

Electrical triggering devices initiate sample collection by activating each automatic water sampler when the water level reaches a predetermined stage. Complete hydrographs were not always sampled due to mechanical problems or exceedence of sampler capacity.

Weekly, daily and monthly samples are collected using a hand-held bottle or weighted bottle holder as appropriate, and composited in a churn sample splitter in accordance with established IEPA procedures (IEPA, 1981).

Samples collected by the ISCO automatic water sampler are drawn by a peristalic pump through 1/4 inch, (I.D.) tygon tubing that extends from each sampler to the thalweg. Before and after the sample is taken, the pump air purges the suction line, thus minimizing the possibility of cross section contamination. The weighted polypropylene strainer at the end of each suction line is suspended in the stream from an overhead guiding device.

A major drawback of the suspended sediment sampling procedure is that it does not permit sampling close to the streambed. Currently available suspended-sediment samplers only collect water samples from the surface to a point about 0.3 to 0.5 feet above the bottom. These samplers and sampling procedures do not allow the sampling of the layer of streamflow closest to the bottom which is carrying the greatest concentration of coarse particles (bedload). Therefore, bedload is not measured as part of the water quality monitoring. As part of the stream geometry and channel characteristics study (SCC, 1981), particle size distribution analyses of bed material at sites in the Highland Silver Lake tributary network will enable the contribution of bed material to the total suspended load to be estimated.

Water samples sent to the laboratory for routine analyses were collected in plastic bottles with appropriate preservative (Appendix Section). Pesticides and polychlorinated biphenyls (PCB's) samples were collected with specially prepared quart bottles using methods described above and composited directly into a one gallon glass bottle. Fecal coliform samples were collected in specially prepared glass bottles.

Dissolved oxygen, temperature, pH, and conductivity were measured using a Hydrolab 4041 digital meter in the field. The meter is calibrated in the field consistent with the Agency Field Methods Manual (IEPA, 1981).

Biological Sampling (taken from IEPA, 1981)

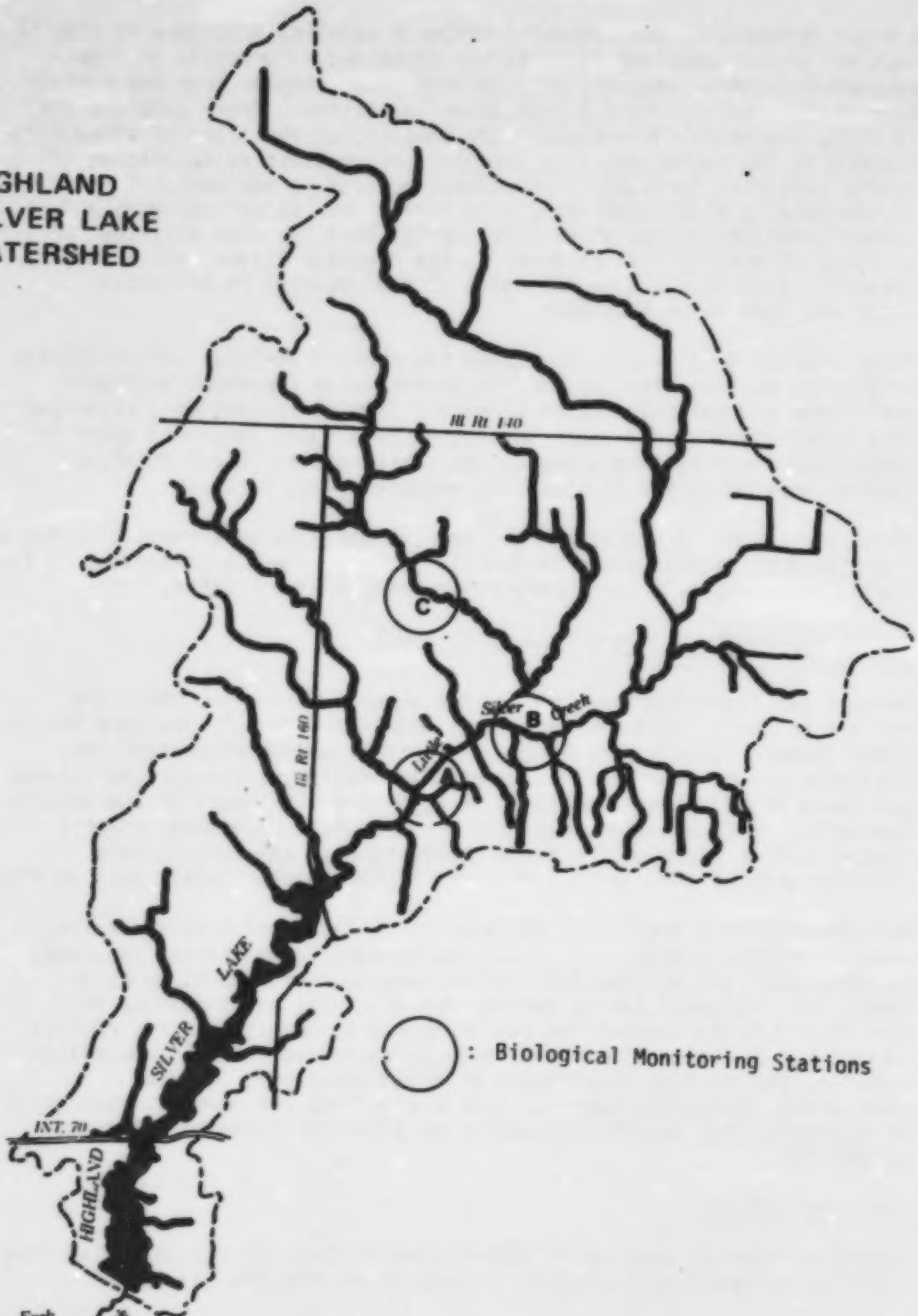
Aquatic macroinvertebrates are animals without vertebrae, which are visible to the unaided eye and can be retained by a U.S. Standard No. 30 sieve (Weber, 1973). Many indegenous species of macroinvertebrates, including worms, crustaceans, insects, and molluscs, inhabit the streams and lakes of Illinois, forming an integral and vital part of the aquatic community. Most macroinvertebrates are dependent upon lower trophic levels such as plankton for their energy supply, and they in turn comprise much of the energy supply for higher trophic levels such as fish.

Macroinvetebrates are relatively easy to collect, and because of their central trophic status, are often used in aquatic monitoring programs. Because many species have life cycles ranging from several weeks to years, and are sensitive to various contaminants, an evaluation of macroinvertebrate communities can be useful in assessing water quality conditions at a given location. Healthy macroinvertebrate communities normally contain high proportions of pollution-sensitive forms. Communities containing fewer sensitive organisms are normally indicative of degraded water quality conditions or other environmental stresses (IEPA, 1981).

Field Collection

Macroinvertebrate sampling at three sites (Figure 11) was conducted thru qualitative sampling techniques in accordance with the Illinois

HIGHLAND SILVER LAKE WATERSHED


Ill Rt 140
Ill Rt 160
C
B
A
Silver Creek
Little
SILVER LAKE
INT. 70
HIGHLAND
E. Fork Silver Creek
: Biological Monitoring Stations

Environmental Protection Agency Field Methods Manual, Section B (1981). The qualitative sampling approach requires an exhaustive sampling of all available habitat types to collect the majority of species or taxa present in that locality.

Qualitative macroinvertebrate samples were collected with a U.S. Standard Number 30 sieve, longhandled dipnet, and by picking organisms from available substrates (e.g. logs and rocks) with forceps. Time expenditure per station for collections was based upon the law of diminshing returns. Sampling was conducted until most available taxa had been collected and was terminated when approximately 10 minutes of additional sampling failed to produce new taxa. All organisms were preserved in the field with appropriate preservative and returned to a regional Environmental Protection Agency office for enumeration and identification. Field notes were recorded at each station for physical parameters and conditions encountered (IEPA, 1981).

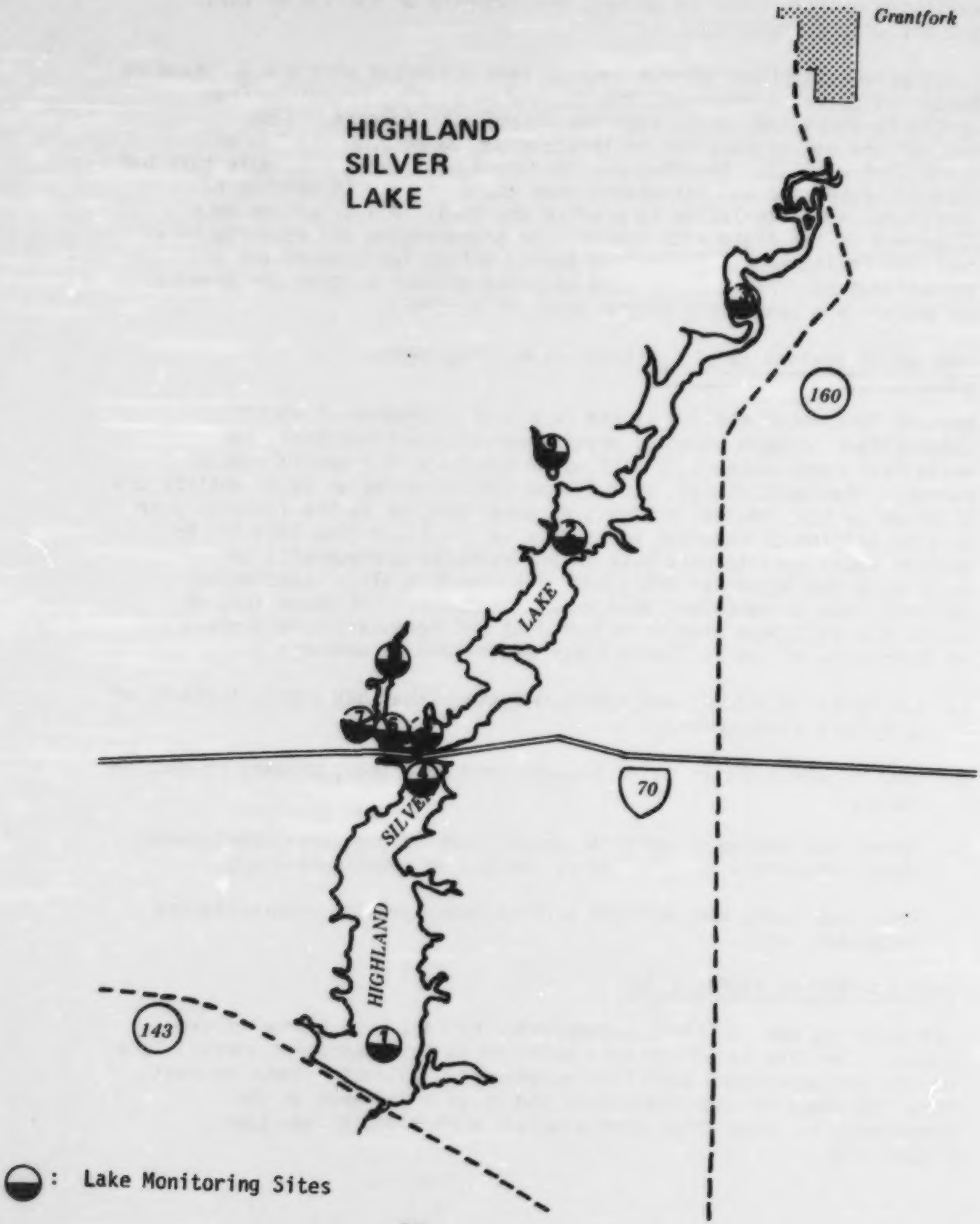
Lake Water Quality Sampling (taken from IEPA, 1980)

Ambient lake water quality is the result of a complex of possible interactions between numerous physiochemical, environmental, and biological constitutents, all of which may vary in a spatiotemporal manner. "Fundamental data used in the determination of water quality are obtained by the chemical analysis of water samples in the laboratory or on-site sensing of chemical properties in the field (Hem 1979.)" An ambient water quality data base is an essential prerequisite to evaluating the impact of RMS's upon lake water quality, developing rational lake or reservoir management strategies. Of necessity, an acceptable data base should include (but not necessarily be limited to) an assessment of the following types of in-lake parameters:

1. Nutrients, physical, and chemical factors that may limit, inhibit, or stimulate plant growth;
2. Factors which affect water transparency and, thus, primary production rates;
3. Extent and degree of vertical stratification and those constituents whose solubility is affected by changes in redox potential;
4. Potential toxic contaminants such as heavy metals, organochlorine compounds, etc.

Field Collection (IEPA, 1981)

Lake sampling was routinely accomplished by boat with a team of two people. Sampling locations were selected to best represent overall lake quality and were based upon lake morphometry, potential input sources, known hydrological characteristics and on-site judgment of the investigators. Nine sites were sampled on Highland Silver Lake (Figure 12).


Grantfork
HIGHLAND
SILVER
LAKE
160
LAKE
70
SILVER
HIGHLAND
143
◒: Lake Monitoring Sites

Chemical and physical measurements made in the field included pH, alkalinity, conductance, water transparency (Secchi), dissolved oxygen, temperature, and site depth. Observations of the weather conditions including air temperature, wind speed and direction, precipitation, and percent cloud cover were recorded on field data forms. Lake color (apparent color), turbidity, aquatic flora, water levels, and general lake usage were noted as appropriate.

Water samples were collected at the top of the water column (approximately one foot below surface) of all site and two feet above the bottom at Site 1. All water samples, except mercury and bacterial, were collected with a 4.2-liter plastic Kemmerer water sampler. Top water samples were taken by immersing the open sampler in the horizontal position to a depth of one foot and closing by hand. When required, bottom samples were taken by triggering the sampler in the conventional manner. All water samples collected by the Kemmerer, with the exception of water destined for dissolved phosphate analysis, were placed in ice, and taken to the laboratory for analysis. Dissolved phosphate water samples were first filtered through 0.45 um pore size Type MF-Millipore filters. Mercury and bacterial samples were collected from surface waters by hand-held bottles.

The pH of water samples was determined using a Hydrolab meter. Alkalinity was determined from titration of a 10 ml sample with 0.02N H_2SO_4 using phenolphthalein and bromcresol green-methyl red indicators. Results were expressed as mg/l $CaCO_3$. Air temperature was taken with a mercury-type field thermometer. Water temperature, pH, dissolved oxygen concentrations and conductance were taken *in situ* using a Hydrolab 8002 digital meter; measurements of DO and temperature were taken at the surface, one foot below the surface, and at two-foot intervals thereafter (i.e., 3 ft., 5 ft., 7 ft., etc). The Hydrolab 8002 meter was calibrated in the field in accordance with IEPA sampling procedures (IEPA, 1981).

Laboratory Procedures (IEPA, 1981)

Upon return to the regional field office, samples were refrigerated or frozen and transported to the appropriate lab for analysis. Table lists all parameters monitored, the laboratory performing the analysis, and provides a brief outline of the specific analytic procedure used in each analysis. Other pertinent information such as detection limits and General Use Standards are also included.

Data Management

All watershed water quality/quantity information is entered into the University of Illinois Data Management System in Champaign, Illinois by

ISWS. All lake quality information is entered into the USEPA "STORET" system. Volunteer Seechi disc transparency and Highland Water Treatment Plant data have been entered into IEPA Tektronix data management system.

Data Analysis

Data analysis is the translation or distillation of measurements via statistical and/or graphical techniques into information needed to solve problems or make interpretation of data; these were curve fitting/trend analysis and hypothesis testing.

The curve fitting/trend analysis technique used was linear regression. This method smooths out the inherent variability in the data and exposes the underlying trend if present. In the final analysis the resulting linear regression equation will be used to estimate the future values of the water quality parameters.

Hypothesis testing is concerned with making decisions concerning a hypothesized value of an unknown population parameter. The Student's t test is the test that will be utilized in hypothesis testing of the watershed data. There are three basic assumptions involved in the use of the test: (1) a normally distributed population for the parameters of interest, (2) the samples are randomly selected, and (3) variances of the population from which the sample sets are drawn are equal (Kleinbaum, 1978).

For purposes of this report, lake data statistical testing was restricted to trend analysis based on between site and seasonal variation. Site means were computed for the sampling period May, 1981 through April, 1982 and compared for between site variation. Lake means were also computed by period (i.e., season) and examined to determine significant differences. All means were compared using Duncan's multiple range test.

Correlation coefficients were computed for the variable matrix and examined to determine which, if any, variable pairs were significantly related. Scatter diagrams for all significant relationships discussed in this report were constructed and examined to insure accuracy of interpretation. All statistical analyses were performed using the Statistical Analysis System (SAS 1975). Multivariate techniques will be used once a sufficiently large data set is obtained.

RESULTS AND DISCUSSION

Water quality sampling in the Highland Silver Lake Watershed started in December, 1981 and continues to the present. Streamflow samples are collected on a daily, weekly, monthly and a storm event basis. All laboratory analyses were performed by Illinois Environmental Protection Agency's laboratories. All water quality data are presented in the Appendix Section. This discussion covers approximately four months of stream data and lake data collected in 1977, 1979, 1980 and 1981. The observations and explanations are only preliminary in nature and should not be considered absolute. All reference to standards or concentration levels not specified as being set by the Illinois Pollution Control Board are values that are recommended in the literature and have no legal basis.

Three periods, based on the amount of surface cover and land management activities, were selected for evaluating seasons and variation in streamflow constiuent concentrations and transport. These periods were selected to conform to the normal agricultural management pattern of the watershed. These periods are:

1) P1: fertilizer, seedbed, and establishment period (April-June);
2) P2: reproduction and maturation period (July-November); and
3) P3: residue period (December-March).

Alberts (1978) used this three season concept to examine seasonal losses of nitrogen and phosphorus in Missouri. There will be some variation in period length from year to year due to climatic factor.

Watershed

The watershed section is divided into four sections; 1) general watershed information, 2) stream water quality, and 3) field runoff water quality runoff. No preliminary trend analysis was attempted on the watershed data due to the low number of observations.

Land Treatment

RMS's are being developed by SCS to meet the goals of the project and concerns of the people. The SCS is working with landowners to control erosion and also with livestock producers to control problems from waste runoff and erosion associated with livestock operations.

The physical effects of soil and water conservation practices are primarily based on control of runoff, rain splash energy, and soil structure. Most RMS's are designed to control either: 1) detachment and transport or 2) only transport of soil particles.

RMS's can be divided into 2 groups. The first, cultural practices, are nonstructural in nature. This group includes no-till, conservation tillage, contouring and stripcropping. The second group consists of structural practices which usually require off-farm equipment for construction. The practices in this group include terraces, grassed waterways, lagoons, and filter strips. Economically, the two classes of practices can be distinguished on the basis of both initial cost and recurring costs. Structural practices are characterized by a relatively high initial cost and lower annual costs, representing maintenance costs. Cultural practices, such as the alteration of tillage system or removal of land from production for some purpose, have a recurring annual cost based on the value of production cost through the application of the practice. These costs in agricultural situations are dependent on the costs of inputs to farm production and the value of farm products to be sold (Lake, 1977).

TABLE 4*

Land treatment accomplishments in Highland Silver Lake RCWP.

	FY 81	FY 82	Total
Landowners Assisted	32	40	62
Landowners applying one or more conservation practices	16	26	42
Conservations plans ("T" value)	1646 ac.	2193 ac.	3839 ac.
Cropland benefited by conservation	824 ac.	2414 ac.	3238 ac.
Pastureland benefited by conservation	6 ac.	318 ac.	324 ac.
Wildlife land benefited by conservation	-	15 ac.	15 ac.
Woodland benefited by conservation	23 ac.	47 ac.	70 ac.
Cropland protected by conservation	749 ac.	1641 ac.	2390 ac.
Pastureland protected by conservation	6 ac.	216 ac.	222 ac.
Wildlife land protected by conservation	-	8 ac.	8 ac.
Woodland protected by conservation	23 ac.	53 ac.	76 ac.

*Supplied by SCS

Precipitation

Rainfall data to date was measured in 5 minute intervals at all recording gauge stations in the watershed. The National Oceanic and Atmospheric Administration's Belleville, Illinois Weather Reporting Station records were utilized to determine the historic precipitation pattern in the Highland Silver Lake Watershed. Table 5 shows historic precipitation and measured precipitation to date.

TABLE 5

Monthly measured and historic (Belleville Station) precipitation averages.

	Historic (Belleville Station)		1981-82 (Watershed Stations Averaged)	
	(in)	(cm)	(in)	(cm)
October	3.06	7.77	3.24	8.23
November	2.99	7.59	0.91	2.31
December	2.26	5.74	*	*
January	2.18	5.54	3.08	7.82
February	2.22	5.64	1.13	2.87
March	3.43	8.71	3.80	9.65
April	4.20	10.67	3.13	7.95
May	4.78	12.14	*	*
June	4.64	11.79	*	*
July	3.94	10.01	*	*
August	3.35	8.51	*	*
September	3.43	8.71	*	*
Annual	40.48	102.81		

*Missing data

Streamflow

Streamflow consists of water from channel interception, overland flow, interflow (where it occurs), and subsurface flow. The route followed by a water molecule from the time it reaches the ground until it enters a overland flow, interflow and subsurface flow is complex and interrelated to each other. Overland flow is that water which travels over the ground surface to a channel, it transports soil particles, crop residue, and chemicals to the water course. Interflow is the water which infiltrates the soil surface and moves laterally through the upper soil layers until it enters a stream channel. Subsurface flow is groundwater that discharges into a stream. Streamflow, according to Pilgrim et. al. (1978), cannot be separated into distinct quantities from different sources, but inferences concerning influences of sources on the time of distribution of water arriving at the stream channel may be made. Soil depth controls, to a large degree, the quantity of water that will be stored in the soil of a watershed and the duration of release to streams thru subsurface flow and its use by vegetation.

Stream discharge has not been estimated at any of the gauging stations due to the lack of information. The outflow of Highland Silver Lake is estimated at the spillway. The lake level is recorded once a day by the water treatment plant operator. These readings are used in conjunction with the spillway rating curve to estimate lake outflow.

Stream Water Quality

The results of analyses of water samples taken at three stream gauging stations (GS-1, GS-2, and GS-3) and the lake outflow (SW) are included in this section. Samples are collected on a monthly, weekly, daily and event basis. Tables 6, 7, and 8 shows the means, standard deviations and number of observations for each of the parameters sampled from December, 1981-March 30, 1982.

TABLE 6

Mean and standard deviations of TSS, TVS, and TURB concentrations for all stream gauging stations for P3 (December-March) analysis period.

	TSS (mg/l)	TVS (mg/l)	TURB (NTU's)
SW ($\bar{X}$)	30.3	15.2	21.7
Stand. Dev.	12.5	6.1	13.8
# of Observations	13	13	13
GS-1 ($\bar{X}$)	138.6	32.4	59.3
Stand. Dev.	189.8	26.6	63.3
# of Observations	26	26	26
GS-2 ($\bar{X}$)	122.2	30.2	84.3
Stand. Dev.	129.1	19.9	76.7
# of Observations	29	29	28
GS-3 ($\bar{X}$)	95.8	28.0	71.2
Stand. Dev.	113.4	19.2	66.6
# of Observations	26	26	22

Suspended Matter

Total suspended solids (TSS) in the water column are composed of volatile and non-volatile fractions. Volatile suspended solids (TVS) are organic in nature, while non-volatile solids (NVS) are generally inorganic. Suspended matter impacts freshwater ecosystems biochemically, chemically, physically, and biologically. Suspended matter can increase the cost of obtaining a suitable water supply for some users. The National Academy of Science -- National Academy of Engineering Committee's (NAS-NAE) Working Party on Water Quality Criteria for European Freshwater Fish has arbitrarily defined four fisheries risk categories and estimated the range of suspended solid concentrations that corresponds to each;

(1) There is no evidence that concentrations of suspended solids less than 25 mg/l have any harmful effects on fisheries.
(2) It should usually be possible to maintain good or moderate fisheries in waters which normally contain 25-80 mg/l suspended solids. Other factors being equal, however, the yield of fish from such waters might be somewhat lower than from those in category (1).
(3) Waters normally containing from 80-400 mg/l suspended solids are unlikely to support good freshwater fisheries, although fisheries may sometimes be found at the lower concentrations within this range.
(4) At the best, only poor fisheries are likely to be found in waters which normally contain more than 400 mg/l suspended solids." (NAS-NAE, 1972).

Classification of suspended matter and associated impacts on freshwater ecosystems (Mulkey, 1977).

Type of Matter	Biochemical, chemical and physical effects	Biological Effects
natural inorganic material (clay, silt, sand)	Sedimentation, erosion and physical abrasion, turbidity (light penetration, habitat change)	Respiratory interference, habitat destruction, light limitation
natural organic matter	sedimentation, dissolved oxygen utilization	food sources, dissolved oxygen effects

The Illinois Pollution Control Board (IPCB) has not specified general use or public/food processing water supply standards for suspended solids. Suspended solids in water are a pollutant when it adversely impacts water quality by itself or acts as a transport mechanism for chemicals toxic or hazardous to man or aquatic life. However, Rule 203(a) of Chapter 3 requires that waters not have unnatural sludge or bottom deposits, floating debris, visible oil, odor, unnatural plant or algal growth, unnatural color or turbidity, or matter in concentrations or combinations toxic or harmful to human, animal, plant or aquatic life of other than natural origin.

Turbidity, caused by suspended silt, clay or other inorganic material (NVS) or by excessive plant or animal matter (TVS), can interfere with aquatic productivity by impeding light penetration and limiting photosynthesis. Excessive turbidity is aesthetically unpleasing and can be a nuisance. When plant life is diminished in quantity or quality (number of species), fish and other aquatic organisms are deprived of food, shelter and sites for reproduction.

Analytical determination of suspended solids by gravimetric methods has an accuracy of less than + 2% for quantities in excess of 10 mg/l. Lower concentrations induce an Tncreasing percentage error due to the accuracy of weighing and dehydration or absorption of water while weighing. The average accuracy of all suspended solids determinations should be ± 2%.

Concentrations of TSS were determined for each sample and averaged by water year, analysis period and station. These data are summarized in Table 6. Comparisons of averages and standard deviations for TSS show the extreme variations in stations.

Of the three tributary gauging stations; GS-3 had the lowest mean TSS and TVS concentrations and GS-1 the highest (Table 6). TSS and TVS show a positive relationship with drainage areas; i.e., increase in concentration with an increase in size of drainage area. There is not a significant difference in TVS concentration between sites, but TVS percentage of TSS changes from 30% at station GS-3 to 23% at station GS-1.

Turbidity decreased from GS-2 to GS-1 and from GS-3 to GS-1. There are not enough observations to determine if this difference is significant and if so what causes it. The decrease in turbidity as drainage area increases probably results from dilution by larger quantities of clearer water and the settling of solids material between gauging stations.

Nutrients

Two problems are associated with nutrients in the aquatic environment: the water may be toxic to humans, animals, or fish when the concentration of certain nutrient forms exceeds a critical level; and euthrophication may be accelerated. Nitrogen, phosphorus, and potassium are essential nutrients for plant growth. Free floating aquatic vegetation, such as phytoplankton, depends on dissolved nitrogen and phosphorus compounds for its nutrient supply. Growth of these aquatic species may be limited by the availability of other nutrients. Dense algal growths sometime occur in water resources that periodically receive increased concentrations of nutrients. These algal growths are generally undesirable and impair the use of the resource by the public. The major sources of nutrients in streamflow are geochemical weathering, fertilization and direct deposition from atmospheric sources. Nutrients from fertilizer can come from runoff of agricultural land or from groundwater return flow draining agricultural land. Nutrients also come from runoff and leachate from animal waste in livestock operations or from the animal waste disposal systems.

TABLE 7

Mean and standard deviations of NH3, TKN, N23, PTL, and DSP concentrations for all stream gauging stations for P3 (December-March).

	NH3	TKN	N23	PTL	DSP
SW ($\bar{X}$)	0.44	1.65	0.82	0.32	0.34
Stand. Dev.	*	*	*	*	*
# of Observations	2	4	2	4	1
X (GS-1)	1.61	3.49	1.73	1.24	0.25
Stand. Dev.	*	1.35	*	1.73	*
# of Observations	4	12	4	12	3
GS-2 ($\bar{X}$)	1.87	3.85	1.77	0.81	0.33
Stand. Dev.	*	1.07	*	0.19	*
# of Observations	3	13	3	13	2
GS-3 ($\bar{X}$)	0.82	2.84	1.78	0.80	0.22
Stand. Dev.	*	0.69	*	0.69	*
# of Observations	3	11	3	11	2

*Insufficient sample size to calculate a meaningful standard deviation.

Phosphorus (P)

Phosphorus (P) is a key metabolic nutrient and the supply of this element often regulates the productivity of natural waters. In natural systems, P occurs as the orthophosphate anion (PO_4^{3-}) which may exist purely in organic forms (H_2PC_2- and HPO_4^{2-}) or be incorporated into an organic species (organic P). Under certain circumstances inorganic orthophosphate may exist as a poly or condensed phosphate. A secondary distinction is made between particulate and dissolved forms of P, the split conventionally being made at 0.45 um. Particulate matter is easily removed by filtration in the field with filtered samples analyzed for dissolved phosphorus (Ryden, et al, 1973).

P in its many forms in stream water originates from biological processes, geophysical erosion, commercial fertilizers, animal wastes, leachate and geochemical weathering of bedrock. Geophysical erosion is the process of physical breakdown of bedrock and smaller particles. Geochemical weathering dissolves and transports constituents to the streams. Rates are controlled by characteristics of climate, soils, topography, biotic agents and bedrock formations (Fredricksen, 1979). PTL from commercial fertilizers and animal waste enters the stream ecosystem from leaching and percolation thru the soil matrix.

Total Phosphorus (PTL)

The Illinois Pollution Control Board (1977) has established a general use standard of 0.05 mg/l for PTL in any lake or stream at the point where it enters a lake. A general index of maximum desirable concentrations is as follows; 0.10 mg/l in flowing, 0.05 mg/l for streams flowing into lakes and reservoirs, and 0.025 mg/l in lakes and reservoirs (U.S. Environmental Protection Agency, 1976).

The overall, short-term impact of surface runoff derived P on standing waters is expected to be high because a large proportion of the average annual discharge of TP occurs over only short periods of time during the annual cycle. Furthermore, the impact of the PTL load carried in streams is expected to be greater during late spring and early summer when aquatic microorganisms are in the potentially active growth phase (Ryden, et al, 1973).

The average concentrations of PTL by station, and the individual measurement period are shown in Table 7. The individual observations are listed in the data section of the Appendix Section. GS-1 had the highest mean PTL concentrations and SW the lowest. The decrease in PTL concentrations between the lake outflow (SW) and GS-1 probably results from dilution, biological uptake and fixation by sediment.

Dissolved Phosphorus (DSP)

In terms of water quality PTL data are not accurate indicators because this measure does not determine the portion of P available for aquatic plant growth. A better assessment of pollution potential is an estimate of DSP which is readily available for plant uptake and consequently, has an immediate impact on algal growth (Mueller, 1981).

There is no general use standard for DSP. Table 7 shows the means and standard deviations of DSP analysis period and station. Due to the lack of samples no explanation is attempted concerning DSP dynamics.

Nitrogen (N)

Most of the nitrogen (N) in a stream has a terrestrial origin. Major sources of N are atmospheric deposition, biological fixation, fertilizers, and leachate from animal wastes. The forms of N in water include dissolved molecular N, proteins and amino acids, ammonia, nitrate (NO_3), and nitrite (NO_2). Loss of N to streams seems to be regulated primarily by biological processes (Likens, 1977) and geochemical reactions in parent material and bedrock (Fredricksen, 1979). Stored N in the soil is utilized by vegetation and returned partly to the soil as litter fall when plants die. Organic N is unavailable for immediate plant use, it is mineralized to more available forms (NH_4-N, NO_3-N) by biological activity.

Sediment can be a source of N to the aquatic environment. Suspended solids in streamflow may have adsorbed or complexed with forms of N either organic or inorganic compounds. Clay minerals and amorphous material, fine grain sediments, have chemically active surfaces which adsorb N compounds (Loughnan, 1969). Legumes, can fix large amounts of N in the soil which can subsequently leach into surrounding waters.

Total Kjeldahl Nitrogen (TKN)

Analysis for total Kjeldahl nitrogen (TKN) measures both ammonia and organic nitrogen. TKN minus ammonia nitrogen is equivalent to the organic N level. Both of these forms occur in organic detritus resulting from natural biological activity. Since ammonia and organic N are both possible contributors to the nutrients pool, their quantification is important in assessing the amount of nitrogen available for biological activities (Sefton, 1980).

Concentrations of TKN were determined for each weekly streamflow sample and averaged by period of analysis and station. These data are summarized in Table 7. Comparisons of averages with standard deviations for TKN shows the extreme variations at stations. SW has the lowest mean TKN concentration and GS-2 the highest.

Nitrates-Nitrites (N32)

Fertilizers, biological fixation, mineralizations and nitrification input nitrate (NO3-N) into the aquatic system. Denitrification, plant uptake, immobilization by soil organic matter and leaching are processes by which NO3-N leaves the system. NO3-N lost from the terrestrial system through soil leaching is the dominant source observed in stream water.

Specific agricultural activities associated with NO3-N are disposal of animal waste and fertilization. Anhydrous ammonia and urea are the principal forms of commercial fertilizer applied presently. Animal manure is a form of fertilizer within this watershed due to the livestock operations. All three of these fertilizers are a source of nitrate, because the breakdown of anhydrous ammonia, urea, and animal manure generate NO3-N.

Concentrations of N32 were determined for each weekly streamflow sample and averaged by period of analysis and by station. These data are summarized in Table 7. Due to the lack of samples no explanation is attempted concerning N32 dynamics.

Ammonia (NH3)

Ammonia is the most reduced inorganic form of N in water. Analysis of water samples normally includes ionized ammonia (ammonium NH4+) and unionized ammonia (NH3) with results expressed as total ammonia N. N fixing organisms (algae, bacteria etc.) living in symbiotic association with plants in soil or water reduce (elemental) N to NH3 and the NH4-N ion.

NH3 is a highly soluble compound resulting from either the decomposition of nitrogenous organic matter (plant or animal wastes) or the microbial reduction of NO3 or NO2-N under anaerobic conditions. NH3 associated with clay minerals enters the aquatic environment through soil erosion. Soils containing large amounts of vermiculitic or illitic type minerals have the capacity for fixing NH3 (Willrich, 1970). Commercial fertilizers to improve crop yields contain highly soluble HN3 and NH4 salts. When the concentration of such compounds exceeds the immediate plant requirements, precipitation or irrigation waters carry these nitrogen compounds into the aquatic system (McNeely, 1979). The animal wastes from feedlots and in other areas of contaminant (storage and distribution facilities) can act as sources of NH3 in surface wastes.

NH3-N is a non-persistent, non-cumulative toxic substance and in low concentrations presents no physiological detriment to man or livestock. Fish cannot tolerate large quantities of NH3-N since it reduces the oxygen carrying capacity of blood resulting in suffocation (McNeely, 1979). For general use waters, the Illinois Pollution Control Board (1977) specified that NH3 should not exceed 1.5 mg/l, while USEPA has recommended setting a limit of 0.02 mg/l on the unionized form (NH3) for protection of aquatic life.

NH3 concentrations did not exceed the 1.5 mg/l limit established by the Illinois Pollution Control Board, only one sample exceeded, 1.0 mg/l. However, NH3 concentrations at all three stations frequently exceeded the 0.02 mg/l limit that USEPA recommended (Appendix Section).

Table 7 shows the mean and standard deviation of NH3 concentrations by station for P3. Comparisons of the means and standard deviation shows the extreme variation between stations.

Heavy Metals, Trace Elements and Pesticides

While most trace elements occur naturally in the environment, extensive use of metals in industry often results in concentrations greatly exceeding natural levels. Certain heavy metals are known to be highly toxic to aquatic organisms and cumulative in the food chain (Hesse, 1972). Because accumulation of heavy metals may result in complex changes in the structure and stability of aquatic ecosystems (McFarlane, 1978), a multitude of studies have been conducted to document metal accumulation in aquatic environment (Hesse, 1972; Kleinert et al. 1974; and Mathis, 1971) (Sefton, 1980). All heavy metals and related trace elements were anayzed monthly at all tributary stations.

The results of the monthly sampling have not been finalized.

Fecal

Fecal coliform (FC) and streptococcus (FS) are being measured at Stations GS-1, GS-2 and GS-3 and the feedlot site as part of the Highland Silver Watershed project. FC bacteria although not harmful in themselves, indicate that a potential hazard to human health exists. Water with FC bacteria may contain fecal matter that can transmit disease causing bacteria and viruses.

The ratio of FC to FS is used to determine if pollution is from human or animal feces. Estimated per capita contributions of FC and FS for animals were used to develop the following FC/FS ratios: (APHA, 1980).

Species	Ratio
Human	4.4
Duck	0.6
Sheep	0.4
Chicken	0.4
Pig	0.4
Cow	0.2
Turkey	0.1

A ratio greater than 4.1 is considered indicative of pollution derived from domestic wastes composed of human excrement whereas ratios less than 0.7 suggest pollution due to non-human sources. Ratios between 0.7 and 4.1 usually indicate wastes of mixed human and animal sources. No fecal samples were taken during this analysis period.

TABLE 8

Mean and standard deviations of COD, TEMP, pH, DOXY, and COND for all stream gauging stations for P3 (December-March) analysis period.

	COD	TEMP	PH	DOXY	COND
SW ($\bar{X}$)	33.5	5.1	7.1	9.4	130.4
Stand. Dev.	*	3.5	0.8	3.5	44.6
# of Observations	4	9	9	8	9
GS-1 ($\bar{X}$)	68.9	5.4	7.3	10.6	358.2
Stand. Dev.	26.3	5.0	0.6	0.9	107.1
# of Observations	9	9	12	10	12
GS-2 ($\bar{X}$)	89.8	6.6	7.2	10.5	341.1
Stand. Dev.	37.8	5.4	0.4	1.8	115.2
# of Observations	12	12	12	11	12
GS-3 ($\bar{X}$)	82.8	5.4	7.5	11.3	334.0
Stand. Dev.	35.1	4.8	0.5	2.7	63.2
# of Observations	8	11	11	10	11

Insufficient sample size to calculate a meaningful standard deviation.

Organic Matter Demand

Organic matter in natural waters includes a great variety of organic compounds. Collective parameters, such as chemical oxygen demand (COD) and biological oxygen demand (BOD) are used to estimate the total quantity of organic matter present.

BOD is a measure of the amount of oxygen required by microorganisms to decompose the organic matter in a water sample under a specific set of conditions. COD is a measure of the total amount of oxygen which is required to completely oxidize all of the organic matter in a sample to carbon dioxide and water.

The COD of water increases with increasing organic matter concentrations COD may also be used to estimate BOD. COD exceeds the BOD of water due to inability of aerobic bacteria to completely oxidize the more resistant organic constituents under the conditions of the BOD test.

In addition to oxygen depletion and resulting changes in aquatic life, decomposing organic matter contributes or causes color, taste, and odor problems in surface water. Such problems are difficult to solve, yet their impacts upon people are highly significant.

COD is not a pollutant itself, but it is a measure of organic pollution. A COD load can pose a threat to the aquatic environment by depressing the dissolved oxygen concentrations to levels that affect aquatic organisms. No water quality guidelines for COD have been proposed. GS-2 had the highest mean COD concentration and SW the lowest (Table 8).

Temperature

Temperature may be defined as the condition of a body which determines the transfer of heat to, or from, other bodies. Physical, biological and chemical processes in the aquatic environment are affected by temperature. Temperature variations are part of the natural climatic regime. Natural bodies of water may exhibit seasonal and diurnal variations. Aquatic organisms have both an upper and lower temperature limit for optional growth, spawning, egg incubation and migration. These limits vary from species to species.

Table 8 shows the mean and standard deviations of temperature by station, and analysis periods.

Specific Conductance

Specific Conductance (conductivity) is a numerical expression of a water's ability to conduct an electrical current. It is measured in micromhos per centimeter (umhos/cm) corrected to a standard temperature, $25^{o}C$. Specific conductance provides a good indication of the changes in a water's composition. It is particularly sensitive to variations of dissolved solids, but provides no indication of the relative quantities of the various components. As more dissolved solids are added, the water's specific conductivity increases. Specific conductance in natural surface waters has been found to range from 50 to 1500 umhos/cm. Groundwater usually has elevated specific conductance (McNeely, 1979).

COND did not vary drastically among gauging stations. SW had the lowest mean COND concentration due to lake dynamics.

Dissolved Oxygen (DO)

Oxygen is one of the gases that is found dissolved in natural surface waters. The amount of DO in natural water varies since it is dependent upon temperature, salinity and turbulence of the water, and atmospheric pressure. The concentration of DO is subject to diurnal and seasonal fluctuations that are due, in part, to variations in temperature, photosynthesis activities and river discharge. Typically the concentration of DO in natural surface water is less than 10 mg/l (McNeely, 1979).

The DO content of water is an indicator of the biochemical condition of the water at that time and place. Fish and other desirable clean-water biota require relatively high DO levels at all times. Streams with large loads of organic material, however, may have oxygen -- consuming organic and inorganic reactions that deplete oxygen to levels unfavorable for the clean-water species. The DO content is an indication of the status of the water with respect to balance between oxygen-consuming and oxygen-producing processes at the moment of sampling (Hem, 1978).

pH

pH indicates the balance between the acids and bases in water and is a measure of the hydrogen ion concentration in solution. pH values reflect the solvent power of water. A pH range from 6.5 to 8.3 units is acceptable in drinking and for the protection of the aquatic environment, the pH should be within the range of 6.5 to 9 units (International Joint Commissions, 1977).

Table 8 shows the mean and standard deviations of pH values recorded by station, and analysis period. Mean pH did not exceed the recommended drinking or aquatic protection range of pH values.

Field Monitoring

There are eight field sites in the Highland Silver Lake Watershed. These sites are sampled on an event-runoff basis. For water quality parameter significance, please refer to the proper subsection of the Stream Water Quality Section.

TABLE 9

Mean and standard deviations of TSS, TVS, TURB, TKN, PTL and COD concentrations for all field sites for P3 (December-March) analysis period.

	TSS (mg/l)	TVS (mg/l)	TURB (NTU's)	TKN (mg/l)	PTL (mg/l)	COD (mg/l)
F1 $(\bar{X})$	142.2	42.2	98.3	2.8	0.78	65.0
Stand. Dev.	172.5	23.0	78.7	*	*	*
# of Observations	6	6	6	1	1	1
F2 $(\bar{X})$	116.5	33.0	54.0			
Stand. Dev.	*	*	*	*	*	*
# of Observations	2	2	2			
F3 $(\bar{X})$	37.0	21.0	18.0			
Stand. Dev.	*	*	*	*	*	*
# of Observations	1	1	1			
F4 $(\bar{X})$	65.1	20.7	53.5	2.6	0.39	54.5
Stand. Dev.	83.3	15.8	63.1	*	*	*
# of Observations	9	9	9	3	3	2
F5 $(\bar{X})$	90.4	27.5	79.4	3.0	0.42	83.7
Stand. Dev.	97.4	16.4	654.8	*	*	*
# of Observations	8	8	8	3	3	3
F6 $(\bar{X})$	161.0	34.5	101.7	4.2	0.66	104.5
Stand. Dev.	197.7	29.1	93.2	*	*	*
# of Observations	10	10	10	2	2	2
F7 $(\bar{X})$	246.9	34.4	109.2	2.12	0.26	55.0
Stand. Dev.	268.1	18.7	99.5	1.63	0.2	*
# of Observations	12	12	12	5	5	3
F8 $(\bar{X})$	122.3	85.3	72.8	683.0	206	3365
Stand. Dev.	70.8	51.8	*	*	*	*
# of Observations	10	10	10	3	3	3

Status of Agricultural Activities on the Field Sites

Field Site	P3 Cover	% Cover	P1 Cover
1	Corn Stubble	70	Reduced till beans
2	Winter Wheat	100	Disked wheat stubble
3	Corn stubble/wheat	50	No till beans Disked wheat stubble
4	Winter wheat	90	No till second crop beans
5	All types	N/A	All crops
6	Corn stubble	70	Beans
7	Winter wheat timber	100	No till second Crop beans, timber, plowed wheat stubble

Field site 5, cover crop varied by field. There is a number of fields within the drainage area.

Suspended Material

Suspended materials (TSS) is composed of both organic (TVS) and inorganic (NVS) particulate matter. Tables 9 shows the extreme variation in TVS and TSS concentrations between stations.

Field site F had the highest mean TSS concentrations. Field sites 1, 2, 6 and 8 had mean TSS concentrations of over 100 mg/l. The high mean TSS concentration represent more than just agricultural runoff; two other sources contributed to the concentration: 1) overflow from a plugged roadside ditch and 2) overland flow across a burned sloped area immediately adjacent to the stream. All sites had a mean TVS concentration of less than 50 mg/l. TURB values showed no trend.

Total Kjeldahl Nitrogen (TKN)

Analysis for TKN measures both ammonia (NH3) and organic nitrogen. Due to the low number of observations no statistical analysis was attempted.

Total Phosphorus (PTL)

Samples from Field Sites 1, and 8 exceeded the Illinois General Use Standard. All of Field Site 8's sample concentrations exceeded 5.0 mg/l. Due to the low number of observations no analysis was attempted.

Organic Matter Demand

Mean COD values all exceeded 50.0 mg/l. Field Site 8 had the highest.

Lake Monitoring

Silver Lake reservoir is located on the East Fork of Silver Creek. The watershed is about 30,946 acres in size and contains approximately 51 miles of streams. The major tributary is Little Silver Creek which drains the northern and eastern portions of the watershed.

TABLE 10

Location, physical description and morphometry of
Highland Silver Lake, Madison County, Illinois

Lake	
Latitude	38° 46' 07"
Longitude	89° 41' 55"
Basin	Kaskaskia
Segment	A03
Maximum length	4 1/2 miles
Surface acres	550.0 acres
Maximum depth	25.0 feet
Mean depth	10.0 feet
Length of shoreline	12.00 miles
Bottom slope	0.40
Storage volume	5,500 acre feet
Retention time	0.52 Year
Annual capacity loss	0.41 percent
Ratio of drainage area and lake capacity	5.5
Watershed	
Major tributary	Little Silver Creek
Drainage area	30,638
Area excluding lake	30,040

IEPA, 1978

Lake Water Quality: Introduction

Three Highland Silver Lake locations designated as Sites 1, 2 and 3, have historically been monitored by the IEPA. This historical numbering system has been retained and explains the lack of an ordered appearance to site numbering depicted in Figure 4 or 5. Site 4 and 5 were located on the west and east side respectively of the Interstate 70 bridge. These sites were selected because it was anticipated that the mid-lake constriction formed by the bridge might lead to differences in water quality, especially transparency. Sites 6, 7 and 8 were established to monitor the largest bay in the lake. Originally, full owner participation and cooperation for the watershed draining into this bay was sought. It was felt that a shorter response time would be required to see water quality improvements in the bay as contrasted to the lake as a whole. At present, not all land owners/users in this bay area are operators in the RCWP project. Site 9 was added several months after initial sampling began; this site was located in a small bay connected to the main body of the lake by a concrete culvert approximately six feet in diameter. Maximum site depth occurs at Site 1 which is located near the dam. Depth at this site is 28 feet compared to the shallowest site (Site 3) where depth is approximately three feet.

Preliminary results of the Highland Silver Lake Monitoring Effort are discussed individually by parameter below. A short narrative explaining the relevance of each parameter to overall lake water quality introduces each section followed by a discussion of seasonal and between site variations. In general, site means (average constituent values for a sampling location) are compared and between site variations noted. Period means (agricultural periods as defined earlier) are examined in some cases and several significant simple correlations are presented. The final section compares Highland Silver Lake water quality for May 1981 - April 1982 with mean water quality values obtained for 63 Illinois lakes monitored in 1979.

VOLUNTEER LAKE MONITORING PROJECT (IEPA, 1982)

Summary

Highland Silver Lake, a multipurpose reservoir in south-western Illinois, was sampled on 11 dates between May 1 and October 31, 1981 under the Illinois EPA's Volunteer Lake Monitoring Program. Volunteers recorded Secchi disc transparency, total depth, and field observations at three to nine sites and reported results to the Illinois EPA.

The average Secchi disc transparency of Highland Silver Lake (13.8 inches) ranked 73rd of the 87 lakes monitored by volunteers in 1981 (rank 1 is clearest, 87 is least transparent). (Figure 13). This average transparency was less than the four feet minimum recommended for swimming by the Department of Public Health and was in the range generally associated with use impairment problems for Illinois lakes.

A spatial trend of increasing transparency from the headwaters to the dam was apparent in Highland Silver Lake. Little seasonal variation in clarity was noted. Field observations of a brown or brownish-green water color throughout the sampling indicated that the transparency was influenced primarily by sediment.

Site 1 on Highland Silver Lake is deep enough to thermally stratify during the summer. Since the lower limit of its euphotic zone (estimated at twice the Secchi depth) is generally less than the total depth, low bottom water dissolved oxygen values, associated water quality problems, and limitation of fish habitat may be expected during summer stratification.

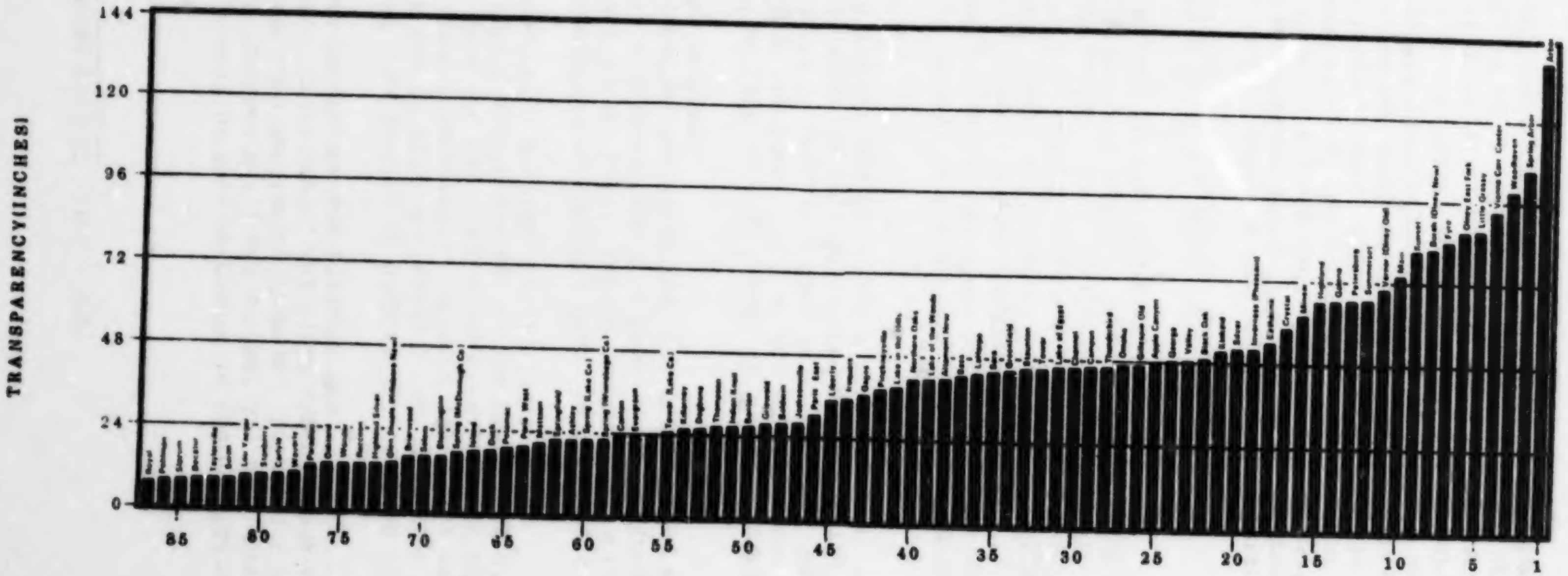
Highland Silver Lake is undergoing the process of eutrophication, as evidenced by transparency readings and field observations of algae, weed, and sediment problems. Protection from further degradation is critical. If nutrient and sediment inputs were controlled, lake quality would probably improve; failure to control inputs will probably result in continued rapid eutrophication. Lake managers should continue to identify sources of nutrient and sediment input and take steps to control them before the lake becomes further degraded.

TURBIDITY AT THE WATER TREATMENT PLANT

Turbidity is the term used to describe the degree of opaqueness produced in water by suspended particulate matter. The kinds of materials creating turbid conditions in a given body of water are as varied as the biotic and abiotic composition of the surrounding terrain, inflowing streams, and the lake itself. Silt, clay, particulate organic and inorganic matter, plankton and other microorganism may all contribute substantially to the quantity and proportions of particulate matter available. The nature of materials causing turbidity is important, because of its physical properties, potential chemical interactons, and total loads. Turbidity is not a uniform parameter since the quantity and quality of suspended particulate matter is so variable in nature (Reid, 1961).

FIGURE 13 SECCHI TRANSPARENCY RANKING OF 87 LAKES

1981 ILLINOIS VOLUNTEER LAKE MONITORING PROGRAM



Turbidity has been measured twice daily at the Highland Water Treatment Plant since January, 1976. The results are expressed in NTU's (Nephelometric Turbidity Units) from August, 1977 to the present. Before August, 1977 it was measured in JTU's (Jackson Turbidity Units). There is no valid basis for the practice of converting NTU's to JTU's or vice-a-versa.

Figure 14 indicates that mean monthly turbidity in water taken from Highland Silver Lake has been decreasing. Close inspection of the data reveals, as expected, a general trend of lower turbidity levels during December, January, and February. Historically, these months have only 16% of the long term annual which usually occurs as snowfall on frozen ground. Whereas peak concentrations are expected during April and May due to the normal precipitation and land management patterns within the watershed. Land management activities during April and May are usually related to planting and seedbed establishment which cause soil disturbance and thus expand potential source areas for suspended solids.

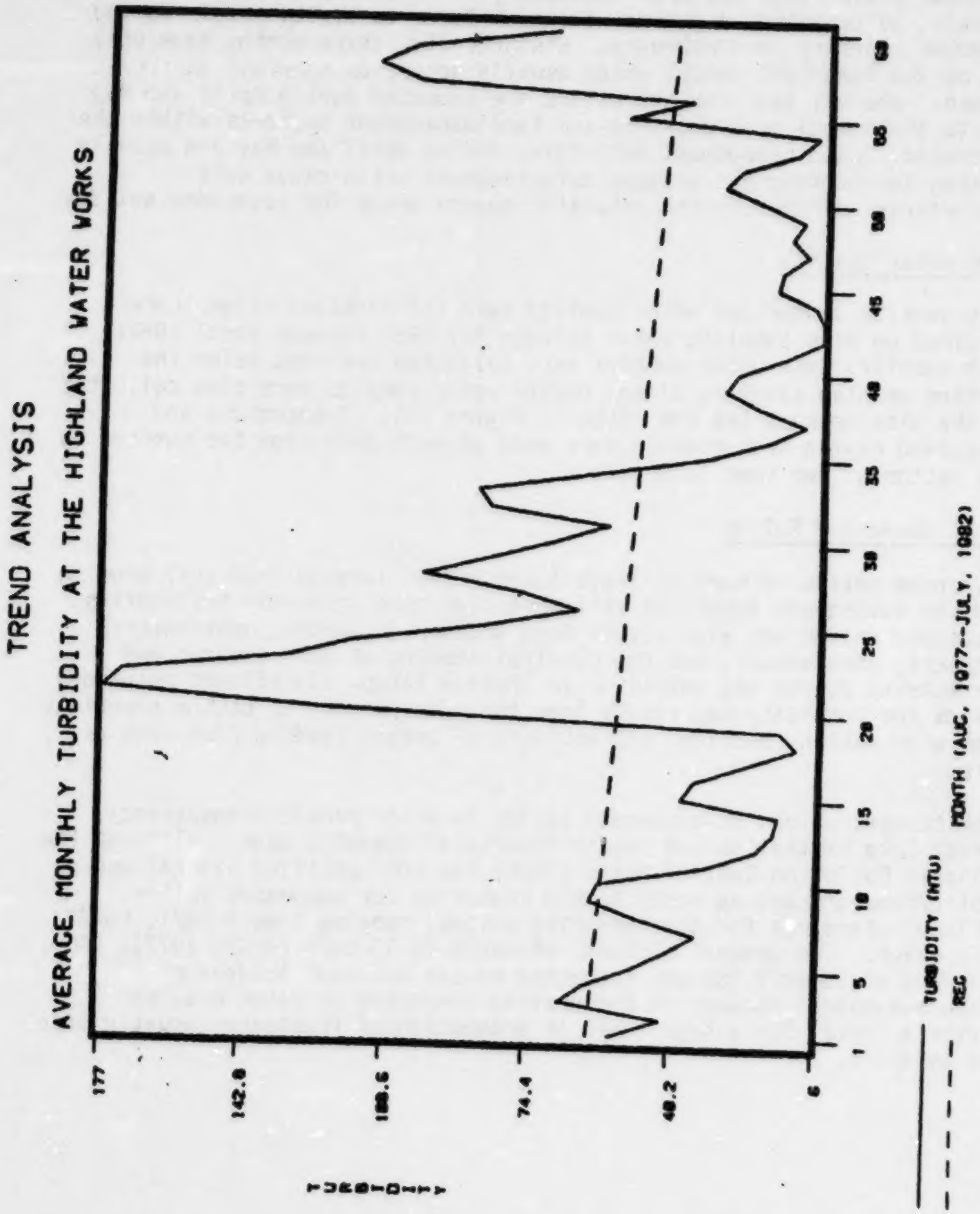
Lake Water Quality

This section summarizes water quality data for Highland Silver Lake obtained on nine sampling dates between May 1981 through April 1982. On each sampling date water samples were collected one foot below the surface at nine sampling sites; bottom water samples were also collected at the site nearest the dam (Site 1; Figure 28). Temperature and dissolved oxygen measurements were made at each site from the surface to the bottom at two feet intervals.

Total Suspended Solids

Suspended solids in many Illinois lakes result largely from soil erosion and the subsequent runoff of soil particles into reservoir tributaries. Suspended solids may also result from industrial wastes, construction projects, mine wastes, and the detrital remains of both aquatic and terrestrial plants and animals. In shallow lakes, significant suspended solids and turbidity may result from the resuspension of bottom materials from wind action, boating, and activity of bottom feeding fish such as carp.

High concentrations of suspended solids in water reduce transparency, affect lake aesthetics and impact beneficial domestic uses. Although the Illinois Pollution Control Board (IPCB) has not specified general use or public/food processing water supply standards for suspended solids, effluent standards for deoxygenating wastes, ranging from 5 mg/l, to 37 mg/l exist. The general effluent standard is 15 mg/l (IPCB, 1977). A standard of 25 mg/l TSS was suggested by the National Academy of Science-National Academy of Engineering Committee on Water Quality Criteria (1972) for a high level of protection of freshwater aquatic life and wildlife.



TREND ANALYSIS
AVERAGE MONTHLY TURBIDITY AT THE HIGHLAND WATER WORKS
TURBIDITY
177
142.8
108.6
74.4
40.2
6
1
5
10
15
20
25
30
35
40
45
50
55
60
MONTH (AUG, 1977--JULY, 1982)
TURBIDITY (NTU)
REG

Total suspended solids (TSS) in water are composed of volatile and non-volatile fractions. Volatile suspended solids (VSS) are organic in nature (algae, other organisms, detritus), while non-volatile solids are generally inorganic or organics resistant to volatilization. Computation of the percentage of the total suspended solids which are volatile and non-volatile may indicate whether reduction in transparency in lakes is due to organic or inorganic turbidity (Sefton, 1978).

Seasonally, spring rains are expected to be the period of maximum runoff and consequentially highest turbidity and suspended solids. Maximum observed total suspended solids (TSS), 630 mg/l, was recorded at Site 9 in April 1982 after a period of seasonally heavy rains. For the period studied, TSS rarely exceeded 100 mg/l except in late spring and early summer (Figure 15). Mean TSS values compared by site using Duncan's multiple range test are presented in Table 11. Statistically mean TSS values at uplake sites (i.e. Sites 2, 3, and 9) could not be separated; however, the Site 9 mean was statistically significantly different from means of sites located closer to the dam. Despite the inability of the rather conservative Duncan's multiple range test to distinguish between site means, a trend in decreasing concentration downlake (i.e., towards the dam) was clearly evident. Mean concentrations at up lake sites (Sites 2, 3, and 9) were two to four times greater than at the up lake sites. Sites 5, 6, 7, and 8 all exhibited similar means; Sites 4 and 1 evidenced lower means. TSS data were grouped by period and means compared using Duncan's multiple range test. Results indicated that the Period 1 mean ($\bar{x}$ = 112.9 mg/l) was statistically significantly greater than Period 2 ($\bar{x}$ = 38.5 mg/l) and Period 3 ($\bar{x}$ = 18.7 mg/l) means. Period 2 and 3 means were not statistically different.

Volatile suspended solids (VSS) followed spatial and seasonal trends identical to total suspended solids. Site means were also compared using Duncan's multiple range test and results were similar to those obtained for TSS (Table 12). Comparison of period means showed that Period 1 ($\bar{x}$ = 24.3 mg/l) was significantly greater than Period 2 ($\bar{x}$ = 13.2 mg/l) which was significantly greater than Period 3 ($\bar{x}$ = 3.6 mg/l).

TABLE 11

Mean surface water TSS (mg/l) at nine sites in Highland Silver Lake, May 1981 - April 1982. Duncan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	$\bar{X}$(±SD)	MIN	MAX	GROUPINGS*
9 (5)	178(±253)	35	630	A
3 (9)	114(±89)	19	270	A B
2 (9)	108(±148)	13	430	A B
6 (9)	54.4(±48.0)	14	160	B
8 (9)	50.3(±41.4)	20	140	B
5 (9)	49.7(±56.2)	15	190	B
7 (9)	47.6(±42.4)	12	150	B
4 (9)	39.4(±34.0)	10	110	B
1 (9)	28.2(±20.2)	11	60	B

*Alpha level = 0.05, DF = 68, MSE = 8538

TABLE 12

Mean surface water TVS (mg/l) at nine sites in Highland Silver Lake, May 1981 - April 1982. Duncan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	$\bar{X}$(+SD)	MIN	MAX	GROUPINGS*	
9 (5)	36.8(±33.1)	15	95	A	
3 (9)	23.1(±14.5)	1	44	A	B
2 (9)	22.7(±22.8)	2	65	A	B
4 (9)	15.8(±13.2)	1	46		B
6 (9)	14.9(±11.1)	3	38		B
7 (9)	14.0(±9.5)	0	30		B
8 (9)	13.3(±7.7)	5	30		B
5 (9)	11.2(±9.1)	3	32		B
1 (9)	9.8(±7.8)	2	24		B

*Alpha level = 0.05, DF = 68, MSE = 220

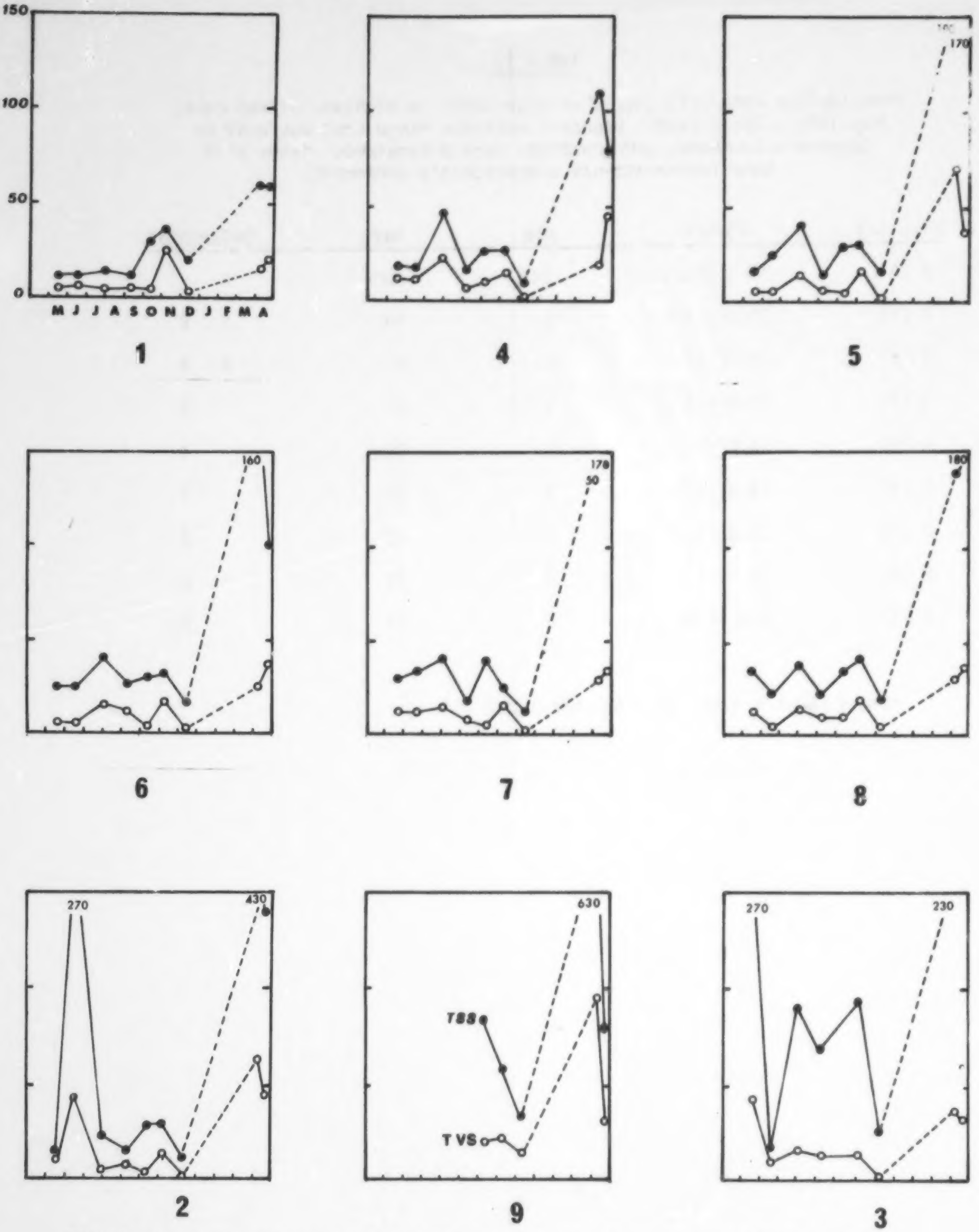


FIGURE 15. Seasonal variation in TSS and VSS at nine sites in Highland Silver Lake, May 1981 - April 1982.

Turbidity

The measurement of turbidity is an attempt to quantify the degree of opaqueness of water due to light scattering and absorption resulting from suspended particulate matter. Turbidity is not a uniform parameter since the quantity and quality of suspended particulate matter is so variable in nature (Reid 1961). Clay, silt, particulate organic and inorganic matter, plankton and other microrganisms may all contribute substantially to the quantity of particulate matter available. The obstruction or absorption of light energy due to turbidity exerts both beneficial and detrimental effects. High turbidity can, for example, reduce the effective zone of photosynthesis, make surface waters more habitable for light-sensitive forms, and increase water temperature by radiation from suspended matter. The nature of materials causing turbidity is important. Pesticides sorbed on suspended inorganic matter for example, may be removed from the water column and carried to the sediments, while suspended organic matter, living and dead, serves as an important food source.

Historically, the most accepted procedure for determining turbidity was based on the Jackson turbidimeter which made use of light penetration through a vertical column of water. For low turbidity samples, calibrated standards were prepared using kaolin with all turbidity results expressed in Jackson Turbidity Units (JTU's). Today results taken from sophisticated photometers are expressed in NTU's (nephelometric turbidity units) which are based on standards prepared from a formazin polymer (APHA, 1975). The USEPA (1976) set criteria for turbidity so the "settleable and suspended solids should not reduce the depth of the compensation point for photosynthetic activity by more than 10 percent from the seasonally established norm for aquatic life."

Turbidity values in Highland Silver Lake were extremely high when compared to the majority of Illinois lakes. Highest turbidities throughout the lake were recorded after winter thaw and during spring rains. Turbidity in the lake steadily declined during summer months; lowest values at all sites were observed in December.

Sites means were computed for the sampling period and compared using Duncan's multiple range test (Table 13). It should be noted here that sampling at Site 9 did not begin until October 1981 and the mean is thus computed from fewer samples and is not representative of the entire period; this is true for all measurements made at Site 9 and for all mean comparisons for this site made throughout this report. Statistically (using Duncan's multiple range test), site means were not different; this can be attributed to the fact that seasonal variability is included. As more data become available, seasonal (not yearly) means by site can be compared, and it is anticipated that statistically significant differences will be found.

TABLE 13

Mean surface water TURB (NTU's) at nine sites in Highland Silver Lake, May 1981 - April 1982. Ducan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	$\overline{X}$(+SD)	MIN	MAX	GROUPINGS*
9 (5)	161.6(±249)	8.2	600	A
2 (9)	118.4(±178)	6.9	530	A
3 (9)	88.4(±96.7)	10.0	265	A
8 (9)	59.2(±82.2)	7.7	225	A
5 (9)	57.5(±84.0)	7.5	210	A
7 (9)	56.5(±76.5)	7.5	210	A
6 (9)	55.9(±81.6)	6.4	225	A
4 (9)	50.3(±66.8)	8.1	170	A
1 (9)	38.7(±45.1)	8.7	140	A

*Alpha level = 0.05, DF = 68, MSE = 12370

Despite the lack of statistically significant differentiation between means, a spatial pattern of decreasing turbidity in a down lake direction (i.e., toward the dam) is evident. Site 1 exhibited the lowest turbidity during the study period with a mean of 38.7 NTU. The Site 2 mean is slightly higher than the Site 3 mean. This disparity is due in part to a single high turbidity reading observed at Site 2 in early April 1982. It is possible that a similarly high turbidity occurred at Site 3 just prior to sampling or this disparity may be real and attributable to significant inputs located between Sites 2 and 3. One such input may be represented by Site 9 which exhibited the highest turbidity recorded during the study period (i.e., 600 NTU on April 8, 1982). Further sampling will enable us to establish whether significant increases in turbidity occur between Site 3 and Site 2 due to inputs other than Little Silver Creek which empties into Highland Silver in the vicinity of Site 3. Turbidities at Sites 5, 6, 7, and 8 were very similar and is not too surprising considering the close proximity of these sites. The bay represented by Sites 6, 7 and 8 is apparently on a relative basis not significant source of turbidity; however, as noted above, the bay represented by Site 9 may be.

It is anticipated that TURB would be directly correlated with total suspended solids and inversely correlated with Secchi transparency. This was the case in Highland Silver Lake; the highly significant inverse relationship between Secchi transparency and turbidity is shown in Figure 16.

Comparison of period means (Table 14) indicates that greatest turbidities were encountered in Period 1 and presumably are attributable to particulates carried into the lake as runoff resulting from spring rains.

Table 14

Mean TURB (NTUs) in Highland Silver Lake by Period. Duncan's multiple range test was used to compare period means and groupings were determined. Means with same letter are not significantly different.

Period	Mean	(n)	Grouping
1	137.5	(34)	A
2	22.8	(34)	B
3	9.3	(9)	B

*Alpha = 0.05, DF = 74, MSE = 8941

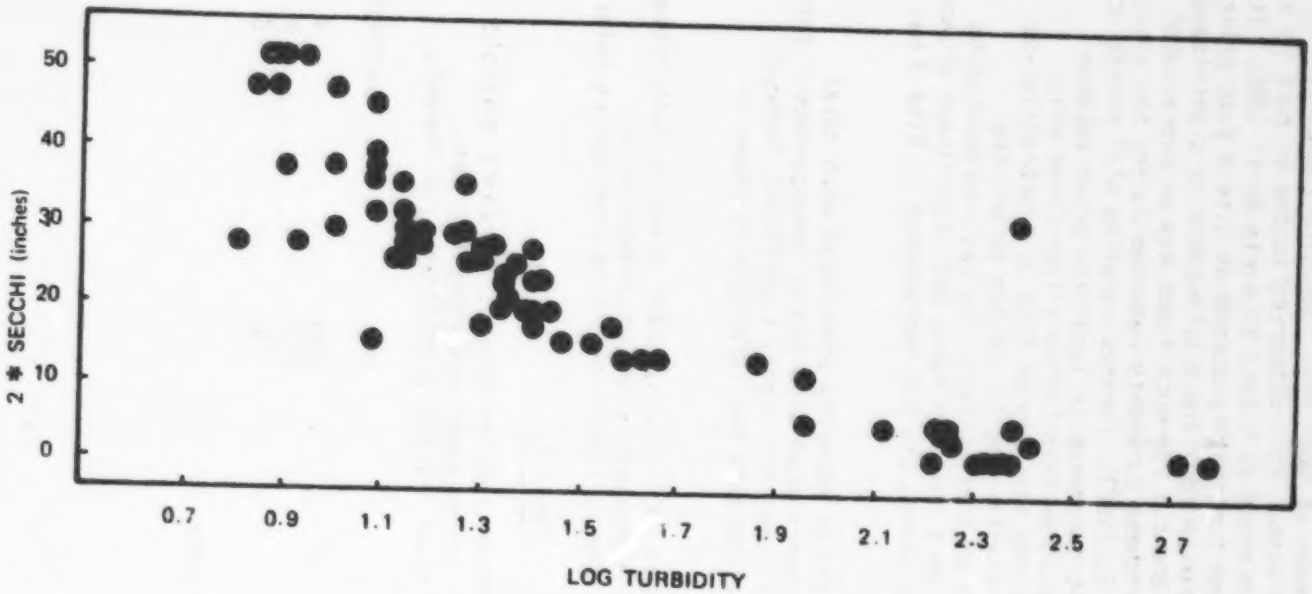


FIGURE 16. Relationship of Secchi transparency with log turbidity at nine sites in Highland Silver Lake, May 1981 - April 1982.

Transparency

Secchi disc visibility is a measure of lake water transparency or its ability to allow vertical light penetration. Secchi disc transparency provides a general index of the clarity of the water and its physical and optical properties, including color, turbidity, dissolved and suspended organic and inorganic material. The depth of water capable of allowing photosynthesis is called the euphotic zone. This zone generally determines the maximum depth for life requiring oxygen to survive and, therefore, limits available habitat and biotic diversity. The depth to which one percent of the light reaches is generally defined as the lower limit of the euphotic zone. Greeson (1971) reported that in Oneida Lake, New York, the one percent penetration depth averaged 13.1 fee, and the concurrent Secchi disc transparency reading averaged 5.6 feet (which equalled the 10.5 percent penetration depth). This is in accord with the conclusion of Hutchinson (1957) that the Secchi disc depth is approximately equivalent to the depth that five to 10 percent of the incident light reaches. In general, the euphotic zone is from two to five times the Secchi depth.

In assessing the results of the National Eutrophication Survey, Allum et al. (1977) classified oligotrophic lakes as those with Secchi depths in excess of 3.7 meters (12.1 feet). Mesotrophic lakes had Secchi depths between 2.0 and 3.7 meters (6.6 and 12.1 feet), while those with Secchi transparency of less than 2.0 meters (6.6 feet) were eutrophic (Sefton 1978).

Typical of most Illinois reservoirs greatest transparency was recorded at Site 1 with values generally decreasing in an up lake direction (i.e., toward Site 3). Greatest transparency recorded for this lake was 26 inches (1.37 feet) and was observed at Site 1 in June 1981 and at Sites 6, 7, and 8 in December 1981. Transparency at most sites was maximal in December and lowest in April. The mean (ISD) Secchi transparency was 11.7 inches. Period means were significantly differenct, indicating that the greatest reduction in transparency occurs in Period 1 ($\bar{x}$ = 8.3 inches).

Based on Allum's assessments of Secchi transparency and trophic state, Highland Silver Lake would be considered eutrophic. It should be noted, however, that relatively few Illinois lakes would not be considered eutrophic. In order to differentiate between the trophic status of Illinois lakes a refinement and increased sensitivity would be required along the eutrophic continum.

Nitrogen

Nitrogen (N), along with phosphorus, carbon, and hydrogen, is one of the major constituents of cellular protoplasm and is a major nutrient affecting the productivity of fresh waters. The forms of nitrogen in water include dissolved molecular nitrogen, organic nitrogen (including such compounds as proteins and amino acids), ammonia, nitrite (NO_2) and nitrate (NO_3). Major sources of nitrogen are atmospheric precipitation, biological nitrogen fixation, and inputs from surface and groundwater drainage. Loss of nitrogen occurs by effluent outflow; by reduction of NO_3 to N_2 by bacterial denitrification, resulting in the return of N_2 gas to the atmosphere; and by the loss of organic and inorganic nitrogen-containing compounds to the sediments (Wetzel 1975). Sediment can serve as a source of nitrogen as well as a sink (Austin and Lee, 1973).

Nitrates and Nitrites (N32)

Nitrification is the biological conversion of reduced nitrogenous compounds to a more oxidized state. This process is generally depicted in two steps mediated largely by two genera of bacteria. Nitrosomonas is largely responsible for the conversion of ammonia (NH_4+) to nitrite, and Nitrobacter is the principal genus involved in the further oxidation of nitrite to nitrate (Wetzel, 1975). Since it is the most oxidized form, nitrate is the more readily available form in oxygenated waters. When both nitrate and ammonia are present, some species of algae uptake ammonia (as NH_4+) in preference to nitrate (Healey, 1973; Round 1966). Nitrate and phosphate are generally considered to be the two nutrients most likely to limit plant growth and as such are routinely monitored in most limnological studies.

N32 concentrations are also major public health considerations. The Illinois Pollution Control Board (1977) public and food processing water supply standards require that nitrate-nitrogen concentrations not exceed 10 mg/l and that nitrite as nitrogen not exceed 1 mg/l. Higher values are especially dangerous to infants who are susceptible to methemoglobinemia. The digestive tracts of infants are not acid enough to prevent the conversion of nitrates to nitrites, and nitrites reduce the oxygen carrying capacity of blood resulting in possible suffocation (Sefton, 1978).

Mean N32 concentrations for the study period was 0.536 mg/l; individual site means ranged from 0.37 mg/l at Site 7 to 0.72 mg/l at Site 2. Inspection of site means (see Table 15) reveals that highest concentrations occurred at the up lake sites (Sites 2, 3 and 9). Unlike most constituents monitored lowest concentrations were not found at Site 1 but at the three sites located in the midwest bay area (Sites 6, 7 and 8).

Highest concentrations were detected in late spring and early summer (i.e., Period 1) and were attributable to influx from spring rains. Unlike most constituents in surface water which steadily declined throughout the summer and fall, increases in N32 were clearly evident beginning in October. These increases were probably attributable to inlake oxidation of reduced inorganic and/or organic nitrogen compounds. A comparison of period means is provided in Table 16 and clearly documents the significant increase in N32 that occurred during Period 1.

TABLE 15

Mean surface water N32 concentrations (mg/l) at nine sites in Highland Silver Lake, May 1981 -- April 1982. Duncan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	$\overline{X}$(+SD)	MIN**	MAX	GROUPINGS*
2 (9)	0.72(+0.87)	0.005	2.7	A
9 (5)	0.68(+0.72)	0.050	1.6	A
3 (9)	0.65(+0.87)	0.005	2.7	A
4 (9)	0.54(+0.43)	0.005	1.3	A
1 (9)	0.50(+0.42)	0.005	1.2	A
5 (9)	0.50 (+0.46)	0.005	1.3	A
8 (9)	0.47(+0.46)	0.005	1.3	A
6 (9)	0.45(+0.44)	0.005	1.3	A
7 (8)	0.37(+0.36)	0.005	1.1	A

*Alpha level = 0.05, DF = 67, MSE = 0.342
**For computational purposes values less than the minimum detectable level (i.e., 0.01 mg/l N) were entered as 0.005 mg/l.

Table 16

Mean N32 by period in Highland Silver Lake, May 1981 - April 1982. Duncan's multiple range test was used to compare means and groupings were determined. Means with same letter are not significantly different.

Period	Mean	n	Grouping	
1	0.84	33	A	
2	0.48	9		B
3	0.25	34		B

*Alpha + 0.05, DF = 74, MSE = 0.25

Kjeldahl Nitrogen

Analysis for total Kjeldahl nitrogen measures both ammonia and organic nitrogen. Kjeldahl nitrogen minus ammonia nitrogen is equivalent to the organic nitrogen level. Both of these forms occur in organic detritus resulting from natural biological activity. Since ammonia and organic nitrogen are both possible contributors to the nutrient pool, their quantification is important in assessing the amount of nitrogen available for biological activities.

Organic nitrogen results from the input of nitrogenous debris from a watershed and from in situ production through normal biological activity; urea is the principal nitrogen-containing end product of protein metabolism. Anthropogenic sources of organic nitrogen include sewage effluents, farm runoff (i.e., livestock wastes and fertilizer), nitrogenous aerosols, and industrial wastes (e.g., urea used in paper industry to soften cellulose) (McNeely et al., 1979).

Surface concentrations of total Kjeldahl nitrogen ranged from 0.5 mg/l observed at several sites on various sampling dates to 4.6 mg/l at Site 9 on April 4, 1982. Comparison of site means (Table 17) revealed no significant differences except between Site 9 and 1. A trend of decreasing concentrations toward the dam was noted. The highest concentrations were routinely found in the culvert bay (Site 9). Concentrations at Site 3 indicated input of significant amounts of Kjeldahl nitrogen from Little Silver Creek.

Comparison of period means indicated significantly higher concentrations of Kjeldahl nitrogen occurred in Period 1 (April - June). The Period 1 mean was 2.01 mg/l as contrasted with Period 2 and 3 means of 1.16 and 0.79 mg/l respectively. Inspection of the correlation matrix indicated a highly significant positive correlation with total phosphorus ($r = 0.9024$, $p = 0.0001$, $n = 77$: Figure 18) and with COD ($r = 0.9150$, $p = 0.0001$, $n = 74$: Figure 17). The correlation between COD and Kjeldahl nitrogen was expected since both parameters are generally good estimates of organic carbon content. It is not possible to unequivocally say whether the positive correlation between total phosphorus and total Kjeldahl nitrogen was due to a correlation with organic phosphorus or non-organic particulate phosphorus; inspection of ratios, however, indicates that the latter is probably true.

TABLE 17

Mean surface water TKN concentrations (mg/l) at nine sites in Highland Silver Lake, May 1981 -- April 1982. Duncan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	$\bar{X}$(±SD)	MIN	MAX	GROUPINGS*	
9 (5)	2.26(±1.37)	1.2	4.6	A	
3 (9)	2.01(±1.05)	0.9	4.2	A	B
2 (9)	1.73(±1.18)	0.7	4.3	A	B
7 (9)	1.39(±0.69)	0.7	2.9	A	B
4 (9)	1.36(±0.90)	0.6	3.1	A	B
8 (9)	1.34 (±0.87)	0.5	3.1	A	B
6 (9)	1.33(±0.74)	0.7	2.9	A	B
5 (9)	1.30(±0.76)	0.6	2.9	A	B
1 (9)	1.04(±0.67)	0.5	2.5		B

*Alpha level = 0.05, DF = 68, MSE = 0.8337

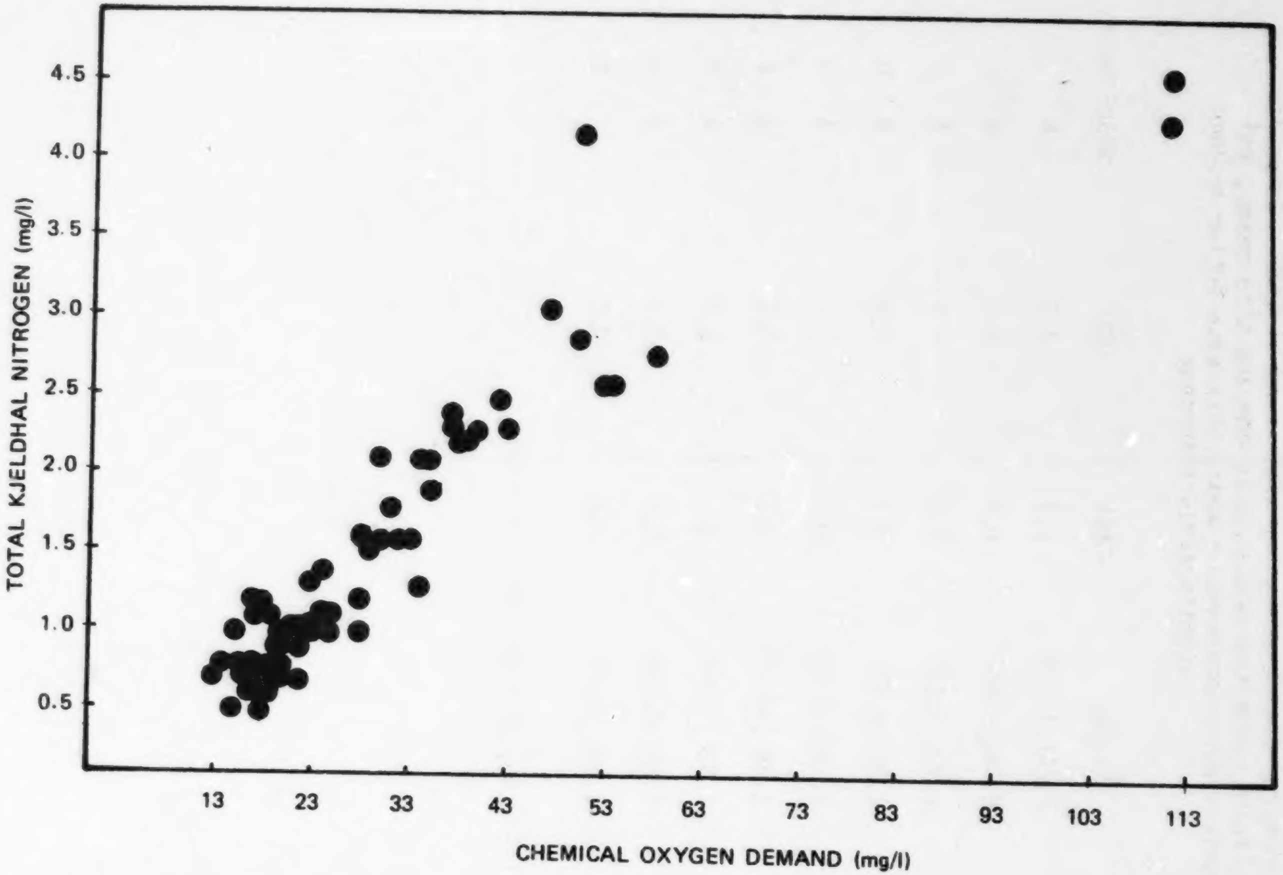


FIGURE 17. Relationship of total Kjeldhal nitrogen to chemical oxygen demand at nine sites in Highland Silver Lake, May 1981 - April 1982.

Total Ammonia Nitrogen

Ammonia is a colorless, gaseous, alkaline compound that is highly soluble in water and occurs as a normal decompositional end product of nitrogenous organic matter (USEPA 1976). Ammonia in water exists as ionized ammonia (ammonium ion, NH_4^+) and unionized ammonia (NH_3) in equilibrium with water and hydroxide ions ($OH-$). Analysis of water samples normally includes both fractions (NH_4^+) and NH_3) with results expressed as total ammonia nitrogen. The percent composition of each fraction is a function of pH and temperature (Roseboom and Richey 1977). The importance of ammonia in freshwater is associated with its extreme toxicity (NH_3) to aquatic organisms and its potential for conversion to nitrogen forms readily assimilated by aquatic plants.

Free ammonia in water is generally derived from bacterial activity resulting in the decomposition of proteins and deamination or removal of an amino acid (Reid, 1961). Natural sources of ammonia in fresh water lakes include precipitation, runoff and dustfall (Roseboom and Richey 1977). Ammonia contributions related to man's activities include urban runoff, animal feedlots, and wastewater effluents (Lin 1977). For general use waters, the Illinois Pollution Control Board (1977) specified that total ammonia-nitrogen should not exceed 1.5 mg/l, while the U.S. EPA has recommended setting a limit of 0.02 mg/l on the unionized form for protection of aquatic life.

Ammonia concentrations in surface water ranged from less than 0.01 mg/l N (the minimum detectable level) to 2.20 mg/l at Site 3 in April 1982 (see Table 18). Duncan's multiple range test revealed no significant differences between sites means; however, concentrations generally decreased toward the dam. In comparison to other Illinois lakes (see Sefton et al. 1980) Highland Lake surface waters were very high with respect to ammonia nitrogen). The mean ammonia concentrations for 63 Illinois lakes monitored during the summer was 0.051 mg/l with a maximum detected concentration of 0.421 mg/l. The Period 1 mean for Highland during this study was 0.535 mg/l contrasted with Period 2 and 3 means of 0.094 and 0.134 mg/l, respectively. Highest ammonia concentrations were clearly correlated with the period of fertilizer application, seedbed establishment and maximum runoff. The most significant source of ammonia remains to be determined. It is anticipated that inspection of ammonia concentrations in runoff from field sites and at gauge sites will allow determination of major contributors.

TABLE 18

Mean surface water ammonia concentrations (mg/l) at nine sites in Highland Silver Lake, May 1981 - April 82. Duncan's multiple range test was used to compare means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	$\overline{X}$(±SD)	MIN	MAX	GROUPINGS*
3 (9)	0.443(±0.691)	0.01	2.20	A
9 (5)	0.366(±0.326)	0.05	0.84	A
4 (9)	0.332(±0.635)	0.01	1.90	A
2 (9)	0.310(±0.306)	0.02	0.81	A
5 (9)	0.268(±0.320)	0.005**	0.89	A
1 (9)	0.248(±0.405)	0.005	1.10	A
7 (9)	0.246(±0.322)	0.01	0.90	A
6 (9)	0.240(±0.357)	0.02	1.00	A
8 (9)	0.219(±0.315)	0.005	0.82	A

*Alpha level = 0.05, DF = 68, MSE = 0.19115

**For computational purposes values less than the minimum detectable level (i.e., 0.01 mg/l N) were entered as 0.005 mg/l.

Phosphorus

Phosphorus (P) is an active element which does not normally occur free in nature. It is found in the form of phosphates in several minerals and it is a constituent of fertile soils, plants, and protoplasm, tissues, and bones of animal life. It is an essential nutrient for plant and animal growth and like nitrogen, it passes through cycles of photosynthesis and decomposition. Phosphorus plays a vital role in energy transfer during cell metabolism. The phosphorus compounds present in water are generally classified as orthophosphates, polyphosphates and organic phosphates of both dissolved and particulate forms (Sullivan and Hullinger 1969; Vollenweider 1968). Since the most readily available forms of phosphorus for plant uptake are non-particulate, it is informative to evaluate dissolved phosphorus (DP) concentrations. Particulate matter is easily removed by filtration in the field, with filtered samples analyzed in the same manner as unfiltered.

Most relatively uncontaminated lake districts are known to have surface waters that contain 0.01 to 0.03 mg/l total phosphorus as P (Hutchinson 1957). To prevent the development of biological nuisances and to control accelerated or cultural eutrophication, PTL as phosphorus (P) should not exceed 0.050 mg/l in any stream at the point where it enters any lake or reservoir, nor 0.025 mg/l within the lake or reservoir (USEPA, 1976). The Illinois Pollution Control Board (1977) has established a general use standard of 0.05 mg/l for PTL in any lake or in any stream at the point where it enters a lake.

The 1973 National Eutrophication Survey (NES) found that phosphorus loadings for the 31 Illinois lakes sampled were generally high, and principally from nonpoint sources. In assessing the NES results, Allum et al. (1977) classified oligotrophic lakes as those with total phosphorus (TP) values below 0.01 mg/l and mesotrophic as those with PTL values between 0.01 and 0.02 mg/l. Eutrophic lakes had PTL values greater than 0.02 mg/l. (Sefton 1978).

The mean ($\pm$SD) PTL concentration in Highland Silver Lake surface water for the period May 1981 -- April 1982 was 0.192 ($\pm$0.185) mg/l PO_4-p. Total phosphorus concentration was significantly correlated with turbidity and TSS, and the relationship is depicted graphically in Figure 19. Mean concentrations by site are given in Table 19; as is clearly evident, concentrations decreased toward the dam. The mean concentration at Site 3 was 0.323 ug/l; when contrasted with a Site 1 mean of 0.115 mg/l, revealing a significant decrease in concentration was apparent.

Comparison of period means indicated a significantly greater input/occurrence of PTL in Period 1 ($\bar{x}$ = 0.052 mg/l). Based on Allum's assessment of PTL concentration, Highland Silver Lake must be considered highly eutrophic.

Seasonal and spatial changes in DSP generally paralleled changes in PTL. The mean DSP concentration in surface water was 0.062 mg/l representing approximately one third of the total. Generally the DSP to PTL ratio at most sites was 1:3; however, at Site 9 the ratio was 1:5, and perhaps indicates greater assimilation by autotrophs.

TABLE 19

Mean surface water PTL concentrations (mg/l) at nine sites in Highland Silver Lake, May 1981 -- April 1982. Duncan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	$\bar{X}$(±SD)	MIN	MAX	GROUPINGS*
3 (9)	0.323(±0.235)	0.058	0.664	A
9 (5)	0.304(±0.281)	0.790	1.6	A
2 (9)	0.266(±0.291)	0.040	0.820	A
7 (9)	0.158(±0.131)	0.030	0.400	A
4 (9)	0.154(±0.126)	0.054	0.350	A
8 (9)	0.154 (±0.133)	0.040	0.400	A
6 (9)	0.153(±0.141)	0.030	0.430	A
5 (9)	0.152(±0.138)	0.040	0.420	A
1 (9)	0.115(±0.093)	0.048	0.290	A

*Alpha level = 0.05, DF = 68, MSE = .0326

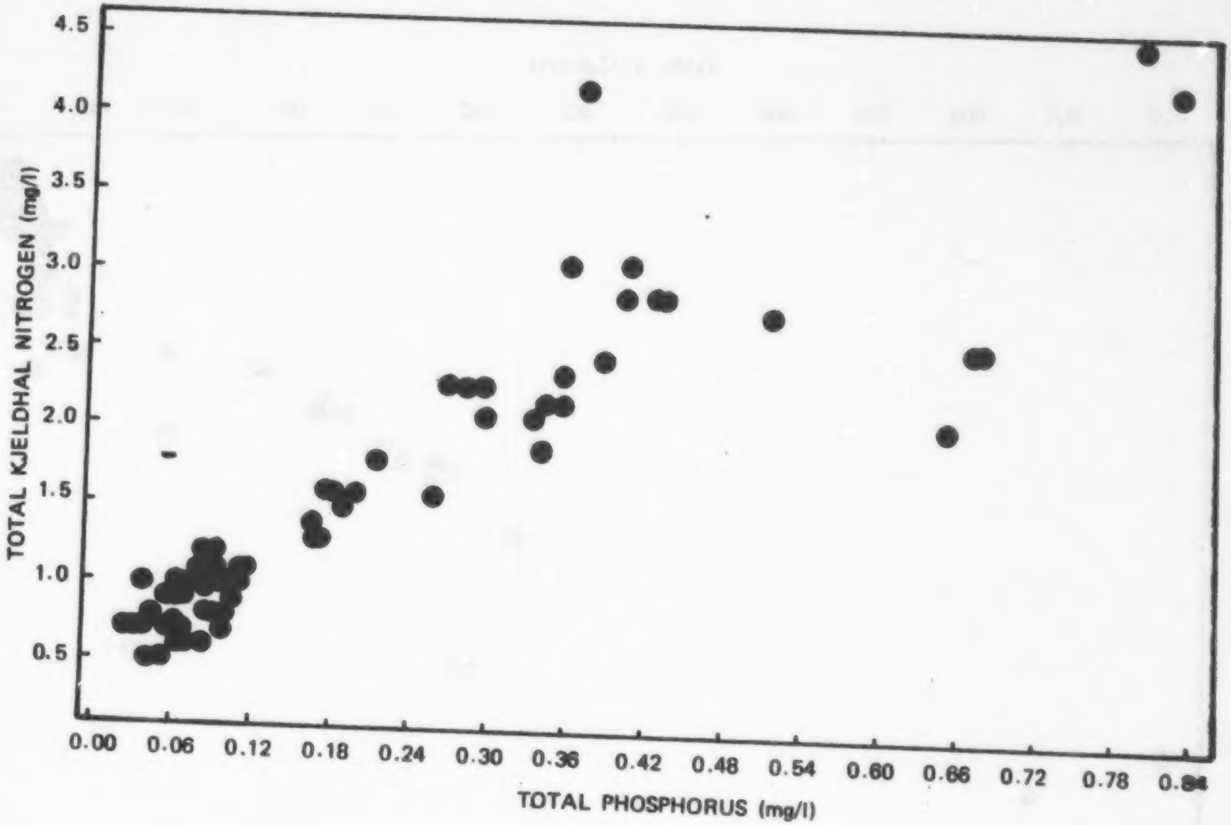


FIGURE 18. Relationship of total Kjeldhal nitrogen to total phosphorus at nine sites in Highland Silver Lake, May 1981 - April 1982.

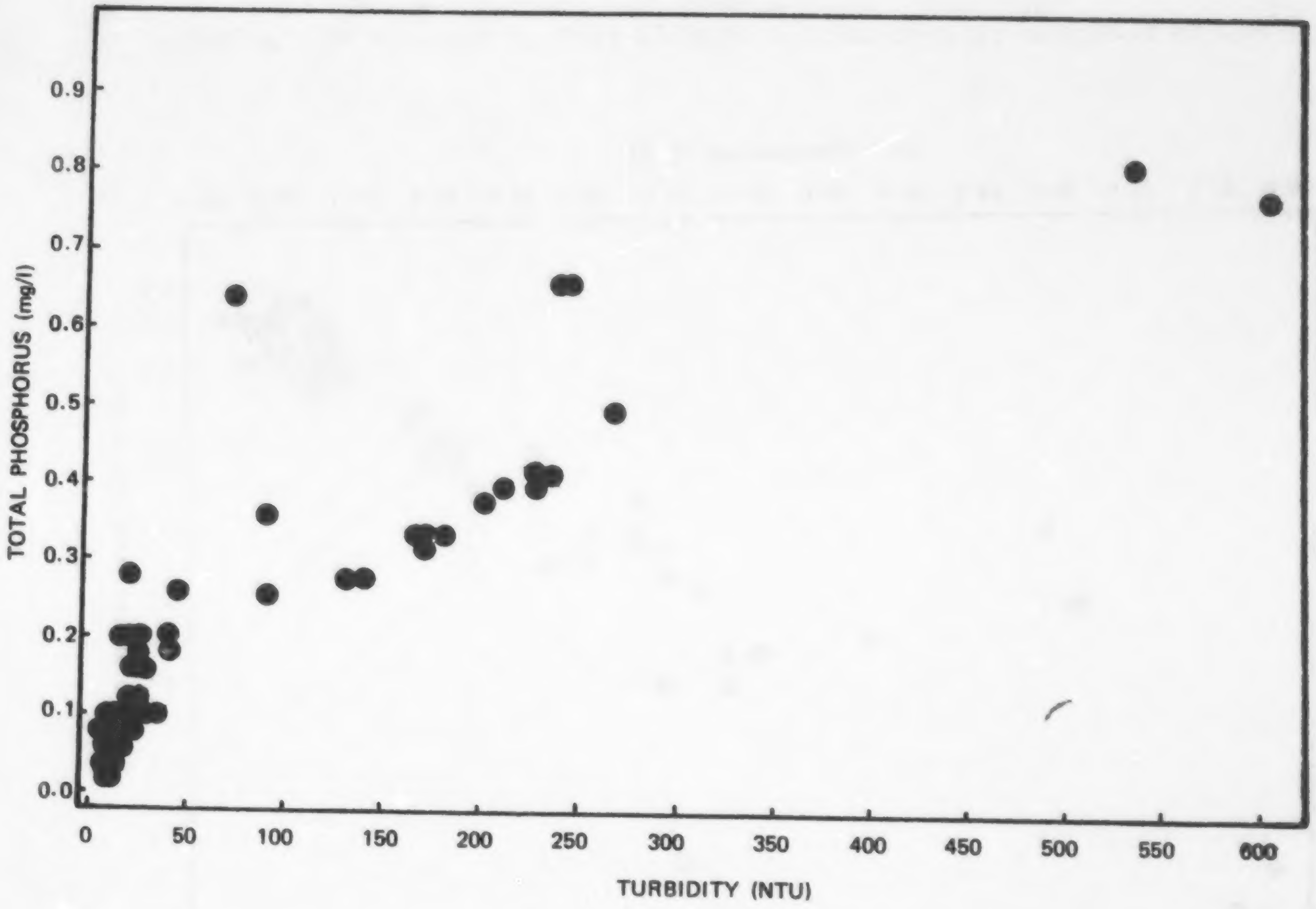


FIGURE 19. Relationship of total phosphorus to turbidity at nine sites in Highland Silver Lake, May 1981 - April 1982.

Organic Matter Demand

Grand mean (±SD) COD for the period studied was 28.6 (±17.3); concentrations ranged from a low of 13 mg/l observed at Site 8 to 110 mg/l detected in surface samples at Sites 9 and 2. Mean concentrations by site are given in Table 20. Duncan's multiple range test was used to compare means; statistically, the Site 9 mean was greater than all down lake sites.

COD is a measure of the organic carbon content as is Kjeldahl nitrogen and consequently a correlation is expected between COD and total Kjeldahl nitrogen. The highly significant relationship is depicted graphically in Figure 17. Seasonal and spatial trends previously discussed for total Kjeldahl nitrogen are applicable to COD.

TABLE 20

Mean surface water COD concentrations (mg/l) at nine sites in Highland Silver Lake, May 1981 -- April 1982. Duncan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	$\overline{X}$(±SD)	MIN	MAX	GROUPINGS*	
9 (5)	47.2(±35.3)	28	110	A	
3 (9)	37.8(±12.8)	20	58	A	B
2 (9)	37.1(±29.8)	18	110	A	B
6 (9)	26.0(±11.1)	17	50		B
8 (9)	25.4(±10.7)	13	47		B
7 (8)	23.8 (±6.3)	16	35		B
4 (8)	23.4(±9.8)	14	43		B
5 (8)	22.4(±7.7)	15	38		B
1 (9)	20.8(±8.5)	15	40		B

*Alpha level = 0.05, DF = 65, MSE = 265

Fecal Coliform

Results of fecal coliform analyses are given in Table 18 for the nine lake sites monitored. A seasonal trend of highest values is indicated for the period of peak runoff in late spring -- early summer. The highest concentration of 9000/100ml was seen at Site 3 in May 1981; all mid and upper lake sites evidenced concentrations greater than 200/100ml. Concentrations at sites nearest the dam (i.e., Site 1 and Site 4) never exceeded 100/100ml. Elevated concentrations were noted in the mid-lake bay area (Sites 6, 7, and 8) on several occasions and most notably in October when most other lake sites evidenced no fecal coliforms. The mid-bay area is possibly impacted by manure from a small cattle operation. Beginning in the summer of 1982 routine lake samples will be analyzed for fecal strep as well as fecal coliforms in an attempt to determine the nature of the contamination.

Comparison of values for Sites 1, 2 and 3 indicates a considerable decrease in fecal coliform occurs toward the dam end of the lake. In general, Illinois lakes, at least during the recreational use period, appear relatively free of fecal contamination (Sefton et al. 1980); Highland Silver Lake may be an exception since more than 20 percent of the samples analyzed contained fecal coliforms greater than 200/100ml.

TABLE 21

Fecal coliform (#/100ml) in water samples taken from Highland Silver Lake, May 1981 -- April 1982.

	1981						1982		
Site	May 21	June 18	July 30	Sept. 63	Oct. 6	Nov. 5	Dec. 10	April 8	April 27
1	58	*	0	*	0	*	20	70	10
2	2	*	*	*	0	*	0	200	10
3	9000	*	0	*	0	*	10	490	200
4	28	*	10	*	0	*	2	100	0
5	380	*	0	*	0	*	10	20	30
6	260	*	10	*	500	*	30	230	40
7	300	*	200	*	800	*	12	220	*
8	350	*	0	*	800	*	8	200	20
9	*	*	*	*	100	*	0	500	40

*Denotes missing value

Chlorophyll

Results of chlorophyll analyses by site are depicted graphically in Figure 20. At the time that this report was written only the results of analyses through December 1981 were available, therefore data on a complete annual cycle have not been evaluated. Preliminary analysis, however, indicates no significant differences between seasons (i.e., agricultural periods).

Peak concentrations at most sites occur in August; however, two sites (2 and 3) evidenced extremely low concentrations at this time. Several sites evidenced slight peaks in December, normally a period of declining phytoplankton production. Given the incomplete seasonal data base it is difficult to speculate on annual trends. The few data points for Site 9 indicate relatively high production in this bay and subjective evaluation by apparent water color suggests high production at other times also. Single highest concentrations to date have occurred in the mid-lake bay (Site 6, 7 and 8). A more complete assessment of chlorophyll trends will be possible as analytical results become available.

TABLE 22

A comparison of period (i.e., seasonal) variation in chlorophyll content (ug/l chlorophyll a) in water samples taken from Highland Silver Lake, May-December 1981. Means were evaluated using Duncan's multiple range test and groupings were determined. Means with same letter are not statistically different.

Period*	$\bar{X}$(±SD)	Minimum	Maximum	Groupings
1	18.9(±13.9)	0	58	A
2	17.6(±11.3)	3	42	A
3	14.9(±8.9)	1	30	A

*Period 1 = fertilizer, seedbed and establishment: April-June
Period 2 = reproduction and maturation: July-November
Period 3 = residue: December-March

Temperature

From an ecological point of view, the thermal properties of water and attending relationships are undoubtedly the most important factors in maintaining the fitness of water as an environment (Reid 1961). Biologically, temperature regulates the composition and metabolism of aquatic communities. All aquatic organisms have definite upper and lower thermal tolerance limits and optimum temperatures for growth and reproduction. Limnologically, temperature plays a vital role in the rate of chemical reactions in water and such physical phenomena as density, viscosity, and oxygen solubility.

One of the most outstanding and biologically significant phenomena of lakes is the seasonal variation in the relationship between water and temperature (Reid 1961). In Illinois, lakes typically undergo seasonal variations in temperature through the water column with distinct stratification occurring in summer months in lakes in excess of 18 feet (Kothandaraman and Evans 1971). Summer thermal stratification occurs in three distinct layers: (1) the warm upper layer known as the epilimnion; (2) the thermocline or metalimnion, a zone of rapid temperature change, and (3) the cold lower layer known as the hypolimnion. A more detailed account of the thermal properties of water and thermal dynamics of lakes may be found in Hutchinson (1957), Wetzel (1975), and Reid (1961).

Maximum depth of Site 1 was approximately 28 feet, this deepest point is apparently small and difficult to locate even with the aid of sonar. The area surrounding the hole is approximately 21 feet; therefore, maximum depth of oxygen and temperature measurements was dependent on sampling personnel successfully locating the deepest point. Highland Silver Lake, however, is sufficiently deep near the dam (i.e., greater than 18 feet) for distinct thermal stratification to occur during summer months.

Spring overturn had already occurred by the commencement of lake sampling in late May 1981 with surface water temperatures beginning to increase. As the extent of the vertical column of water increased; a thermocline was established at Site 1 with maximum rate of temperature change in June and July occurring between 15 and 20 feet below the surface. By early September the water body had warmed almost completely top to bottom with only slight vertical change evident. Cooling temperatures beginning in October signaled the beginning of the fall overturn with an almost unithermal profile apparent. In December surface and bottom water temperature differed by only 0.1°C. Water at this end of the lake was a consistent 5°C top to bottom; ice was beginning to form at Site 3 in the upper end of the lake. Ice cover prevented sampling between January and March. On April 8, 1982 surface temperatures was 5.1°C and bottom water temperature was 8.3°C. By late April, water temperature increased appreciably; surface water temperature 15.6°C and bottom water temperature 14.9°C.

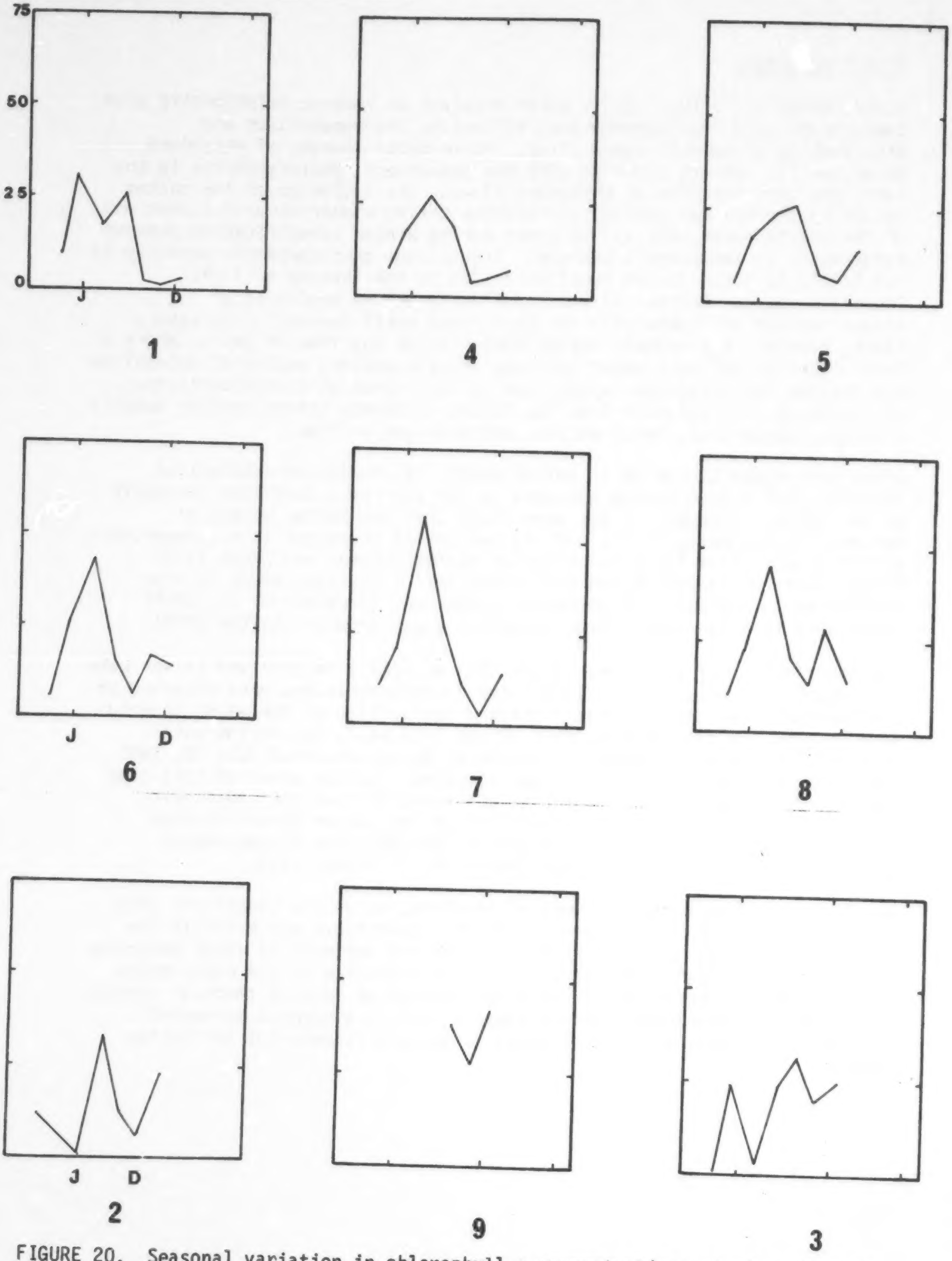


FIGURE 20. Seasonal variation in chlorophyll-a concentrations at nine sites in Highland Silver Lake, May - December 1981.

Dissolved Oxygen

Dissolved oxygen solubility in water displays an inverse relationship with temperature, and like temperature, influences the composition and distribution of aquatic communities. Three major sources of dissolved oxygen exist: direct exchange with the atmosphere, photosynthesis in the lake, and contributions of tributary flows. The isolation of the bottom waters by thermal and density differences during summer stratification and of the entire water body by ice cover during winter stratification prevent oxygenation by atmospheric sources. Significant photosynthetic activity is not likely to occur in the hypolimnion due to the absence of light. Therefore, oxygen trapped in the hypolimnion at the beginning of stratification will generally not be renewed until turnover. Tributary flows, however, may augment oxygen resources at any time of year. Where a lake bottom or influent water contains organic matter, bacterial metabolism may deplete the dissolved oxygen, and certain chemical constituents are reintroduced into solution from the bottom sediments (these include ammonia nitrogen, phosphorus, heavy metals, and hydrogen sulfide).

Dissolved oxygen depletion in bottom waters is considered substantial evidence that a lake system had aged to the eutrophic condition (Brezonik et al. 1969). However, it has been found that the bottom waters of man-made impoundments in Illinois become devoid of oxygen (i.e., anaerobic) within a year after their construction (Kothandaraman and Evans 1975). Oxygen supersaturation in the epilimnion during daylight hours is also considered an indicator of eutrophic conditions (Brezonik et al. 1969) since this usually results from excessive plant growths (Sefton 1978).

The distribution of dissolved oxygen (DO) at Site 1 in Highland Silver Lake is presented in Figure 21. Highest oxygen concentrations were observed in December when low temperatures increased the ability of the water to hold more oxygen. At this time surface DO was 10.9 mg/l, and bottom waters contained 13.0 mg/l. Lowest surface water DO was observed July 30, 1981 when a concentration of 6.1 mg/l was detected. Bottom water at this time was devoid of oxygen, and inspection of Figure 20 indicates anaerobic conditions existed in bottom waters through the summer stratification period. Comparison of Figures 19 and 20 indicate that bottom waters quickly become anaerobic once the thermoline is established.

Due to the shallow nature of most of the lake, anaerobic conditions only persist at the dam site; however, anaerobic conditions may exist at the mud-water interface at mid-lake sites since the sediment no doubt generates a high oxygen demand. The effect of oxygen depletion in the hypolimnion exerts a controlling effect on sediment release of several chemical species including iron, manganese, and phosphorus, and is evidenced by marked differences in concentration of these parameters between top and bottom samples.

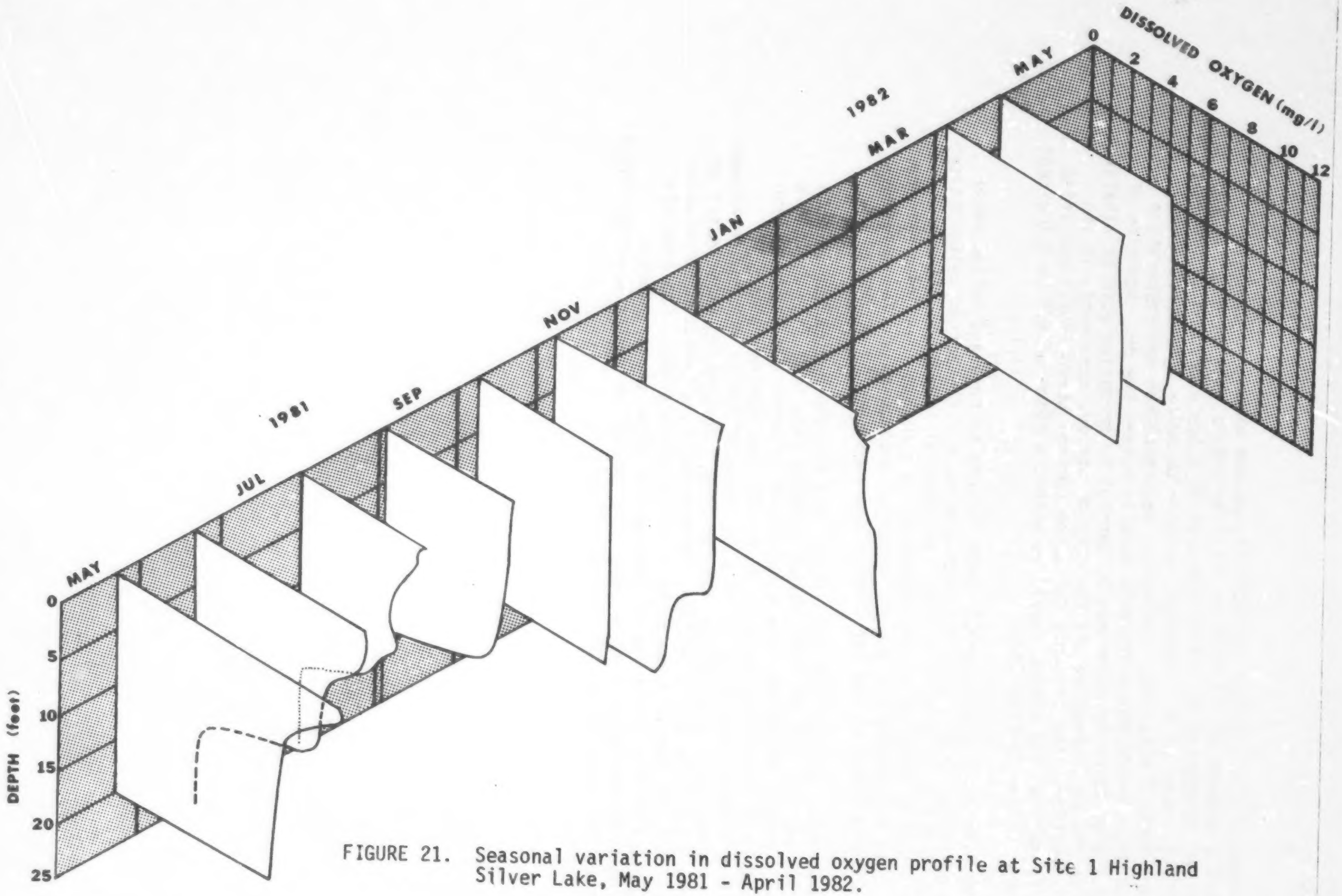


FIGURE 21. Seasonal variation in dissolved oxygen profile at Site 1 Highland Silver Lake, May 1981 - April 1982.

pH

pH, an index of the hydrogen ion activity of the water, is commonly considered a measure of its acid or alkaline nature. As an index of the hydrogen ion concentration, pH is measured on a scale of 0 to 14 (McNeely et al. 1979). A pH of 7 is neutral, while a pH below 7 is considered acidic and above 7 alkaline. Biological decomposition and respiration tend to reduce pH, whereas photosynthesis usually raises the pH. Addition of either acids or bases to water may be harmful by producing acid or alkaline conditions and by increasing the toxicity of various components in the waters. Therefore, the Illinois Pollution Control Board (1977) specified that pH of general use waters should be within a range of 6.5 to 9.0 except for natural causes (Sefton 1978).

pH varied over a relatively small range in both surface and bottom waters. Surface pH ranged from 7.0 to 8.1 with a mean of 7.62; bottom values ranged from 7.0 to 8.0 with a mean of 7.09. No seasonal trends are clearly evident. Bottom water pH values tended to be somewhat lower than surface values, this presumably was due to bacterial metabolism which increased carbon dioxide (CO_2) in the hypolimnion and subsequently decreased pH.

Grand mean ($\pm$SD) pH for Highland Silver Lake for the period May 1981 to April 1982 was 7.5 ($\pm$0.64) with values ranging from 6.2 (Site 2) to 8.8 (Site 9). Lowest pH values were encountered in April and may have been attributable to dilutional effects of runoff from spring rains. A comparison of mean concentration by site revealed little difference between sites. Highest mean site pH was 7.8 for Site 8 contrasted with lowest pH mean of 7.2 for Site 3 (Table 23). Interestingly, a positive correlation was found between Secchi transparency and pH (Figure 22). One possible explanation for this trend was an increase in algal photosynthesis resulting from increased transparency; the removal of carbon dioxide caused a shift to the right (i.e., an increase in pH).

TABLE 23

Mean surface water pH at nine sites in Highland Silver Lake, May 1981-1982. Duncan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different:

Site (n)	$\bar{X}$(+SD)	MIN	MAX	GROUPINGS*
8 (9)	7.79(±0.71)	6.6	8.7	A
4 (8)	7.71(±0.69)	6.6	8.7	A
6 (9)	7.71(±0.58)	6.6	8.3	A
7 (9)	7.67(±0.66)	6.7	8.3	A
5 (9)	7.66(±0.59)	6.7	8.5	A
2 (9)	7.39(±0.72)	6.2	8.3	A
9 (5)	7.30(±0.87)	6.6	8.8	A
1 (8)	7.30(±0.36)	6.7	7.9	A
3 (9)	7.24(±0.69)	6.4	8.1	A

*Alpha level = 0.05, DF = 66, MSE = 0.428

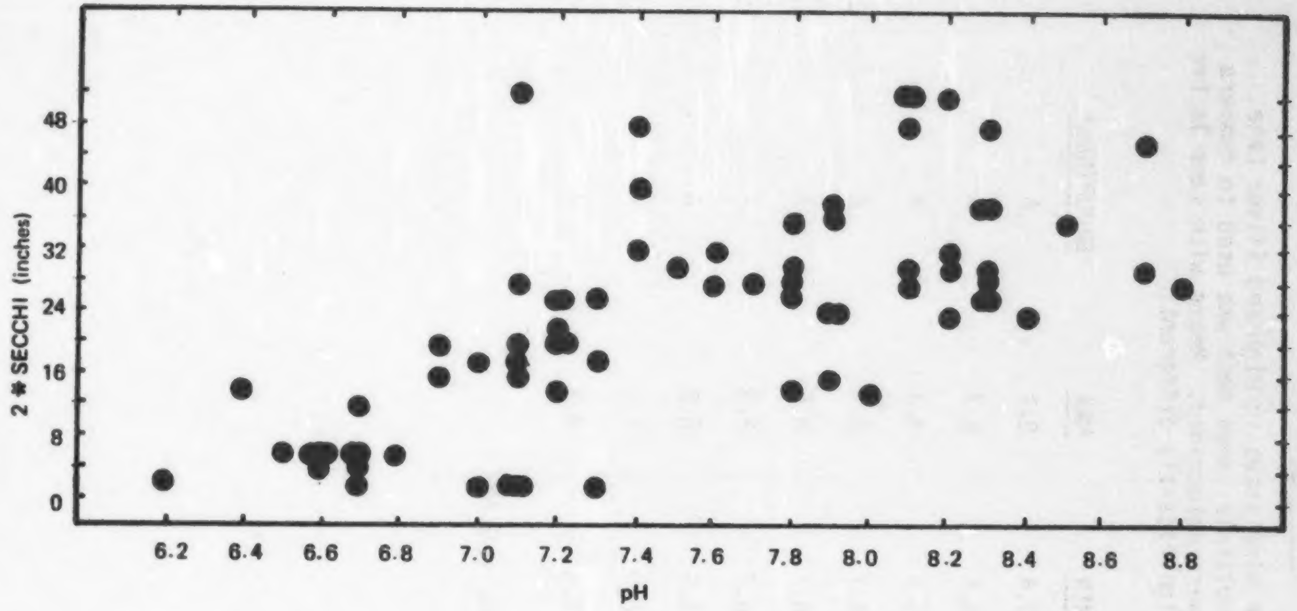


FIGURE 22. Relationship of Secchi transparency with pH at nine sites in Highland Silver Lake, May 1981 - April 1982.

Total Alkalinity

Alkalinity is a measure of water's capacity to neutralize an acid. It indicates the presence of carbonates, bicarbonates, and hydroxides, and less significantly, borates, silicates, phosphates, and organic substances (McNeely et al. 1979). Alkalinity in lakes is primarily governed by the geochemistry of the watershed, and is expressed as an equivalent of calcium carbonate ($CaCO_3$).

Because alkalinity provides resistance to pH changes, it is therefore a measure of the buffering capacity of that water. The carbonate system not only provides buffering capacity, but also a source of carbon for photosynthesis and is thus related to the biological productivity of the water (National Acad. Sci., 1972). The Illinois Pollution Control Board has not stipulated a standard for alkalinity in natural waters. Highly alkaline waters, however, have been reported to have distinctly unpleasant taste, probably because they are generally associated with high values of pH, hardness, and dissolved solids (McKee and Wolf, 1963; National Acad. Sci., 1972)

In general, alkalinity in Highland Silver Lake was low with site means ranging from 54 to 62 mg/l as $CaCO_3$ (Table 24). No spatial or seasonal trends were apparent; although, on several ocassions between site variance was high (e.g. July 1981, late April 1982). No single site consistently evidenced higher or lower alkalinities. Coefficients of variation for site means were generally between 20 and 30 percent.

TABLE 24

Mean surface water total alkalinity (mg/l at $CaCO_3$) at nine sites in Highland Silver Lake, May 1981 - April 1982. Duncan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	X(+SD)	MIN	MAX	C.V.	GROUPINGS*
6 (9)	61.7(±14.6)	40	90	24	A
1 (8)	60.6(±19.9)	30	85	33	A
9 (5)	60.0(±12.7)	40	70	21	A
5 (9)	59.4(±15.7)	35	90	26	A
7 (9)	58.3(±14.6)	40	90	25	A
8 (9)	57.8(±12.0)	40	75	21	A
3 (9)	56.7(±16.2)	35	90	29	A
4 (9)	56.7(±10.0)	40	70	18	A
2 (9)	53.9(±13.4)	40	75	25	A

Conductivity and Total Dissolved Solids

Most naturally occurring elements can be expected to occur in water, their concentration being a function of the elements' abundance and solubility. The geochemistry of a given area is there a major factor in determining the chemical constituents in the waters of its drainage basin. "The total concentration of dissolved substances or minerals in natural waters is a useful parameter in describing the chemical density as a fitness factor, and as a general measure of edaphic relationships that contribute to productivity within the body of water (Reid 1961)."

All salts in solution change the physical and chemical nature of the water and exert an osmotic pressure. Some have physiological as well as toxic effects upon aquatic life. Synergistic or antagonistic interactions between mixed salts in solution may cause the effects of salts in combination to be greater than those effects when the salts occur separately.

Dissolved solids affect aquatic organisms in two ways. In aquatic systems, water balance (i.e., osmoregulation) is controlled by the salinity of the environment, and an organism's ability to survive is a function of the adaptations it possesses for handling the osmotic pressure generated by the surrounding milieu. Secondly, the quality and quantity of dissolved solids present determines the nutritive and mineral values of the water. Greeson (1971), for example, observed that high total dissolved solids (TDS) content in Oneida Lake, New York accompanied high algal production. He concluded that TDS content is an important index of potential productivity because no element, ion, or compound is like to be a limiting factor in nature for algal production when the dissolved solids content is high. Jenkins (1975) found a relationship between TDS and total standing crop of fish. The higher the TDS level, the larger the standing crop of fish in 166 reservoirs. Jenkins considered TDS the most significant index for predicting standing crops of fish (pounds per acre).

A measure of the total amount of ionized material in water can be obtained by determining its electrical conductance. Pure water has a very low electrical conductance; however, the presence of charged particles in solution makes the solution conductive. Empirical data has demonstrated a well defined relationship between total dissolved solids and conductance. The regression line is defined by the formula $KA=S$ where K is conductance in micromhos per centimeter, S is dissolved solids in milligrams per liter, and A is a conversion factor which is generally in the range of 0.55 to 0.75 (Hem 1970). High total dissolved solids may be objectionable because of possible mineral taste (Lin 1977) and costly corrosion damage to water systems (National Acad. Sci., 1972). Because of these factors, the Illinois Pollution Control Board (1977) specified that TDS content shall not exceed 1000 mg/l for general use or 500 mg/l for public and food processing water supplies (Sefton 1978).

As evidenced by site statistics presented in Table 22, conductivity at most sites showed very little variation during the study year. All sites, except Sites 3 and 9, had a mean conductance of 215+2 umhos/cm and a coefficient of variation of approximately ten percent. Results of Duncan's multiple range test used to compare site means (Table 22) indicates that Site 9 evidenced a significantly higher conductivity.

TABLE 25

Mean surface water COND (umhos/cm) at nine sites in Highland Silver Lake, May 1981-April 1982. Duncan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	$\overline{X}$(+SD)	MIN	MAX	GROUPINGS*	
9 (5)	276.0(±81.3)	215	419	A	
3 (9)	247.9(±83.9)	120	394	A	B
7 (9)	216.9(±22.3)	185	255		B
1 (8)	216.8(±17.4)	193	248		B
8 (9)	216.2(±19.4)	195	250		B
4 (9)	215.9(±21.6)	185	250		B
6 (9)	215.8(±22.8)	180	255		B
5 (9)	214.8(±22.6)	180	250		B
2 (9)	214.3(±34.9)	154	264		B

*Alpha level = 0.05, DF = 67, MSE = 1696

Lake Classification and Trophic State

A wide range of physical, chemical, and biotic parameters have been used to describe freshwater lakes and the multitude of descriptive indices and lake classification systems which have evolved have been summarized by Uttermark and Wall (1975); Sefton (1978); and Van Benschoten (1978). Lakes have been historically classified by nature of geologic origin and more recently on the basis of productivity or trophic status. Traditionally, lakes classified by trophic status have been placed into three broad categories (from Sefton 1978):

1. Oligotrophic lakes have low concentrations of nutrients such as phosphorus and nitrogen and support little plant growth. Biological productivity is generally low, and the waters are clear (Naumanns 1919, 1931; Hasler 1947; Hasler and Ingersoll 1968; Vollenweider 1968).

2. Mesotrophic lakes are intermediate in character between oligotrophic and eutrophic. They are moderately well supplied with nutrients and generally support moderate biological productivity.

3. Eutrophic lakes are nutrient rich and generally highly productive, capable of supporting a large amount of plant growth and other biological activity (Naumann 1919; Hasler 1947; Hasler and Ingersoll 1968; Vollenweider 1968). Eutrophic lakes cover a myriad of water quality conditions, ranging from very desirable recreational lakes that support excellent warmwater fisheries to lakes with undesirable aesthetics and water use limitations (Rogers 1977).

The eutrophication process is classically defined in terms of natural glacial lakes. Glaciated lakes normally begin as oligotrophic bodies of water with stable quality and long natural successional lives. Increases in productivity of their waters are generally brought about by increasing nutrient concentrations. Artificial impoundments, however, frequently inundate rich bottom land soils and normally begin their lives with a high productivity potential. High reservoir productivity is maintained by nutrients and organic materials leaching from bottom soils and runoff from disturbed watershed lands. Many Illinois reservoirs are thus nutrient rich and considered eutrophic soon after construction.

The placement of lakes into groups based on particular characteristics is often necessary to establish management priorities, decisions, and subsequent fund allocations. The necessity of establishing a system to characterize Illinois lakes resulted from existing state and federal mandates. The Illinois Environmental Protection Act (P.A. 76-2429) requires programs to restore protect, and enhance the quality of the environment. Section 314 of the Clean Water Act of 1977 (P.L. 95-217) requires the states to classify all public owned freshwater lakes by eutrophic condition.

A preliminary lake classification and prioritization system was developed for Illinois lakes based primarily on the qualitative data available for each lake. A detailed description of the classification and prioritization methodology and results may be found in the report, "Assessment and Classifications of Illinois Lakes" (Sefton 1978).

Lakes were classified into eight major groups based on their present condition and potential for exhibiting problems. The current lake condition was determined to be excellent, good, fair, or poor by totaling points assigned for water transparency, lake condition judgments, and severity of use impairment from turbidity, algae, or aquatic macrophytes. The cleanest lakes were considered to be those with greatest transparency and with least use impairment (i.e., those with the least number of total points).

The potential of each lake for exhibiting problems with fertility and sediment pollution was determined to be high or low by utilizing the following factors: mean depth, lake capacity/drainage area ratio, and watershed land cover. Deep lakes with high capacity/drainage area ratios and forested watersheds were considered to have the least potential for exhibiting problems with eutrophication and sediment pollution and the greatest potential for improvement upon implementation of pollution controls.

Approximately 56 percent of the lakes assessed in the initial IEPA lake classification effort fell into the "fair to poor quality" category with a "high potential for exhibiting problems." Highland Silver Lake was one of these lakes, receiving 14 total lake condition points and 11 total points for potential problems (Sefton 1978).

A lake prioritization mechanisms was developed in order to highlight those lakes within each group which are most important to the general public on a statewide basis and, thereby, more likely candidates for expenditure of public statewide basis, and thereby more likely candidates for expenditure of public funds for protection, rehabilitation, or management. The criteria utilized in the prioritization - public accessibility, lake size, population served, and usage type and intensity - were assigned numerical values. The individual values were added to give a total priority value between 0 and 100 for each lake. Lakes receiving the lowest total scores were considered least important to the general public on a statewide basis while those with highest values were considered most important. The eight classifications developed for Illinois lakes along with priority rating factors are shown in Appendix Table. Highland Silver Lake, considering its size, was given a relatively high priority rating of 75 using this system.

For purposes of possible trophic state comparison, trophic state index values were computed using equations developed by Carlson (1977). Carlson constructed his Trophic State Index (TSI) such that the zero point on the scale would denote a Secchi transparency depth (SD) greater than any yet encountered; the greatest known SD is 41.6 m for a lake in Japan. The formula was constructed so that a TSI(SD) value of zero is obtained for a Secchi reading of 64 m; a value of 10 is obtained when SD=32 m, 20 for 16 m, 30 for 8 m and so forth. The theoretical limit is infinity; however, the practical limit of 100-110 is reached when transparency is from 0.064 to 0.032 m. Carlson also developed formulae using total phosphorus and chlorophyll a data based on empirical relationships of these two parameters with SD. When considering the results of TSI calculations, one should keep in mind the assumptions on which the Carlson formulae are based: 1) Secchi transparency is a function of phytoplankton biomass; 2) phosphorus is the factor limiting algal growth; and 3) total phosphorus concentration is directly correlated with algal biomass (Sefton 1978). These assumptions will not necessarily hold for reservoirs where suspended solids other than algae are a major source of turbidity.

Highland Silver Lake data violate the basic assumptions made by Carlson as evidenced by lack of correlation between total phosphorus and chlorophyll a (r=0.0037, p=0.9778, n=58) and Secchi transparency and chlorophyll a (r=0.0345, p=0.7969, n=58). Carlson's primary premise relates to the fact that turbidity is controlled by the amount (biomass) of algae in suspension; therefore, as algal biomass increases transparency decreases. One of Carlson's indicies was developed based on an empirical relationship between total phosphorus and chlorophyll a. For this index to be applicable total phosphorus must correlate with algal biomass; in Highland Silver Lake, it does not. For the index using Secchi transparency (SD) to determine trophic state, turbidity must be attributable to algal biomass; in Highland Silver Lake it is not. The correlation of turbidity with chlorophyll a was not significant (r=0.1180, p=0.1814, n=58).

Although Carlson's assumptions have not been met (as is the case in many Illinois lakes) his trophic state index values have been calculated since (a) they do make it possible to compare lakes on the basis of transparency using equation 1; (b) they do afford a trophic assessment on the basis of algal biomass using equation 2 (although the results of this computation should not be used to classify a lake in the classical sense); and (c) assuming that in the absence of high inorganic suspended solids phosphorus is limiting, they can be used to approximate the potential trophic state using equation 3.

Seasonal patterns and site fluctuations in TSI values will parallel exactly changes in the parameters from which they were computed (i.e., total phosphorus, Secchi transparency and chlorophyll a calculations). For comparative purposes, TSI values by period means are presented in Table 27.

TABLE 26

Trophic State Index values calculated according to Carlson (1977) for Highland Silver Lake, May 1981-April 1982. Numbers in parenthesis are sample size (n).

	Period 1	Period 2	Period 3
TSI (TP)	80.9 (34)	71.8 (34)	60.1 (9)
TSI (SD)	90.4 (33)	77.2 (34)	70.3 (9)
TSI (Chlor)	54.7 (15)	56.6 (33)	56.8 (a)

TABLE 27

Mean surface water TSI chlorophyll values at nine sites in Highland Silver Lake, May 1981-April 1982. Duncan's multiple range test was used to compare site means, and groupings were determined. Means with same letter are not significantly different.

Site (n)	$\bar{X}$(+SD)	MIN	MAX	GROUPINGS*
9 (3)	65.5(±2.1)	63.3	67.2	A
8 (7)	58.4(±5.2)	53.1	67.9	A B
6 (7)	58.3(±6.2)	47.2	67.5	A B
7 (7)	57.3(±8.4)	43.5	70.4	A B
2 (5)	57.2(±5.9)	49.6	64.8	A B
5 (7)	55.5(±6.7)	47.8	62.8	A B
3 (7)	54.9(±12.2)	34.2	64.5	A B
4 (7)	53.5(±6.9)	45.1	62.8	B
1 (7)	49.9(±11.8)	34.3	64.0	B

*Alpha level = 0.05, DF = 48, MSE = 68

Lake Water Quality: Overview

During the sampling period May 1981-April 1982, Highland Silver Lake was sampled nine times at eight to nine sites (nine sites beginning in October 1981). The annual mean concentration for the constituents monitored are presented in Table 28; period means are also presented. In 1979, the IEPA monitored 63 lakes located throughout the state, and resultant means and ranges are, for comparative purposes, included in Table 28. Since the 63 lakes studied in 1979 were monitored during the summer recreational period, it is perhaps best to compare these means with the Highland Silver Period 1 means or some combination of the Period 1 and 2 means.

As is apparent from Table 28, Highland Silver Lake is an extremely turbid water body. Comparison of means for Secchi transparency, turbidity, and total suspended and volatile solids for Highland Silver Lake with 63 Illinois lakes clearly indicated that Highland Silver Lake was one of the most turbid lakes in the state. Results also indicated that turbidity was for the most part attributable to non-volatile suspended solids. Chlorophyll a data further indicated little in-lake production compared with most Illinois lakes. It is quite probable that Highland Lake is light limited.

Nutrient levels in Highland Silver Lake are higher than the norm for most constituents (i.e., total and dissolved phosphorus, ammonia and Kjeldahl nitrogen). The only exception is nitrate & nitrite nitrogen; the Highland norm was 0.536 mg/l compared with a mean of 0.904 mg/l for the 63 lakes monitored in 1979. It should be noted; however, that this mean is skewed due to some extremely high values encountered in some east-central Illinois lakes. Highland Lake is apparently well supplied with nutrients, and low phytoplankton biomass can not be attributable to limiting nutrient supply.

As noted above chlorophyll a concentrations are low in Highland Lake and no seasonal variation occurred as denoted by period means. Some between site variation did occur, however. Typically, algal biomass peaks in late spring or early summer when diatoms predominate and then again in late summer when bluegreen algae dominate. Chlorphyll a data, however, indicate a fairly constant seasonal biomass. It might be speculated that decreases in turbidity even with decreased nutrient supply may lead to establishment of a more characteristic flora and increases in seasonal algal biomass.

Highland Silver Lake data violate the basic assumption needed in order to fairly calculate Carlson's trophic index values. These values were calculated, however, for comparison with previously generated values for other Illinois lakes. It is anticipated that close scrutiny of similar data from other lakes would indicate similar conditions although not generally as severe as observed in Highland Silver Lake. Despite the assumptions of Carlson, not all lakes can be expected to be nutrient limited.

In general, Highland Silver Lake can be described as a highly turbid lake, well supplied with nutrients which according to most standards would be considered hypereutrophic.

Table 28. Comparison of mean constituent concentrations in Highland Silver Lake with means obtained for 63 Illinois lakes sampled in 1979.

	$\bar{X}$(±SD) for 63 Illinois Lakes 1979	Range for 63 Illinois Lakes 1979	$\bar{X}$ for Highland Silver 1979*	$\bar{X}$(±SD) for Highland Silver May 1981-April 1982	$\bar{X}$ April-June (Period 1) n=9	$\bar{X}$ July-Nov. (Period 2)	Dec.-March (Period 3)
Secchi Transparency (inches)	38.2(±30.7)	7 to 180	7.7	11.7(±7.1)	8.3	12.7	20.2
Tuirbidity (NTU)	13.1(±17.2)	0.83 to 91.7	84.7	71.8(±110.3)	137.5	22.8	9.3
Total Suspended Solids (mg/l)	16.5(±13.3)	1.8 to 51.8	41.5	69.0(±96.5)	112.9	38.5	18.7
Volatile Suspended Solids (mg/l)	7.1(±5.7)	1.2 to 26.5	7.5	17.0(±15.6	24.3	13.2	3.6
Conductance (umhos/cm)	362(±242)	81.1 to 1799	150	224(±43)	239	209	217
Total Alkalinity (mg/l as $CaCO_3$)	100(±51)	20 to 207	50.8	58.2(±14.0)	59.4	57.2	57.8
pH 8.34(±0.54)	8.34(±0.54)	7.37 to 9.88	7.52	7.54(±0.65)	7.42	7.51	8.12
Nitrate+Nitrite-N (mg/l)	0.904(±1.475)	0 to 7.95	0.721	0.536(±0.536)	0.843	0.253	0.48
Total Kjeldahl Nitrogen (mg/l)	1.021(±0.216)	0.267 to 2.383	1.083	1.492(±0.928)	2.015	1.156	0.789
Total Phosphorus (mg/l)	0.119(±0.185)	0.004 to 1.212	0.235	0.192(±0.185)	0.289	0.132	0.052
Dissolved Phosphorus (mg/l)	0.48(±0.107)	0.000 to 0.706	0.058	0.062(±0.074)	0.090	0.043	0.028
Chlorophyll a (ug/l)	33.5(±29.1)	4.06 to 153.6	16.7	17.7(±12.4)	14.9	19.0	17.6
TSI(SD)	65.3(±10.4)	38.7 to 85.3	84.2	82.1(±13.9)	90.4	77.2	70.3
TSI(Chlor)	68.4(±8.0)	48.4 to 86.6	61.2	56.1(±8.4)	54.7	56.5	56.8
TSI(TP)	63.1(±15.0)	31.3 to 105.3	82.0	74.4(±12.4)	80.9	71.8	60.0

*Samples collected in June and September 1979

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APPENDIX SECTION

APPENDIX A

Summary of monitoring parameters. Sample preservation, methods of analysis, reporting units, and Geneal Use Standards as appropriate.

PARAMETER	SAMPLE CONTAINER	PRESERVATION	METHOD OF ANALYSIS (REFERENCE)	UNITS OF MEASUREMENT	DETECTION LIMITS	ANALYSIS	GENERAL USE STANDARD
Temperature			In sit determination using Yellow Springs Instruments (YSI) model 57 dissolved oxygen meter (1).	^{o}C	nearest 0.1^{o}	Field determination	
Dissolved Oxygen (DO)			In sit determination using YSI model 57 dissolved oxygen meter (1)	mg/l O_2	0.1 mg/l	Field determination	no less than 5 mg/l
Transparency			Secchi disk (2).	feet	nearest 0.1 foot	Field determination	
Total Suspended Solids (TSS)	1/2 gallon polyethylene	refrigeration at 4^{o}C	filtration on glass fiber filter, determination of increase in weight upon drying at 103-105^{o}C(3, p. 268).	mg/l TSS	1 mg/l	Regional IEPA lab	
Volatile Suspended Solids	1/2 gallon polyethylene	refrigeration at 4^{o}C	Loss in weight of TSS filter upon ignition at 559^{o}C (3, p. 2272).	mg/l VSS	1 mg/l	Regional IEPA lab	
Turbidity	1/2 gallon polyethylene	refrigeration at 4^{o}C	Mephelometrically using Hach model 2100A turbidimeter (3, p. 205).	NTU	0.05 NTU	Regional IEPA lab	
Conductivity			YSIU Model 33 S-C-T Conductivity meter or Electrolytic Conductivity Measuring Set, Model MC-1.	umhos/cm	nearest 1 umhos/cm	Field determination	
Alkalinity			Titration of 10 ml sample with 0.02 N H_2SO_4 to phenolphthalein and brom cresol green-methyl red end points (4).	mg/l $CACO_3$	nearest 5 mg/l	Field determination	

PARAMETER	SAMPLE CONTAINER	PRESERVATION	METHOD OF ANALYSIS (REFERENCE)	UNITS OF MEASUREMENT	DETECTION LIMITS	ANALYSIS	GENERAL USE STANDARD
pH			Sargent-Welch model PBL pH meter, calibrated in field.		nearest 0.1 units	Field determination	in range 6.5-9.0
Nitrate + Nitrite-N	8 oz. polyethylene	10 ml - 20% H_2SO_4/1 at 4ºC	Cadmium reduction method on Technicon Auto-Analyzer (3, p. 201).	mg/1 N	0.01 mg/1	Regional IEPA lab	
Ammonia-N (NH_3-N)	8 oz. polyethylene	10 ml - 20% H_2SO_4/1 at 4ºC	Phenate method on Technicon Auto-Analyzer (3, p. 168)	mg/1 N	0.01 mg/1	Regional IEPA lab	1.5 mg/1
Total Kjeldahl-N	8 oz. polyethylene	10 ml - 20% H_2SO_4/1 at 4ºC	Digestion at 370ºC followed by determination of ammonia as above.	mg/1 N	0.1 mg/1	Champaign IEPA lab	
Total Phosphorus	8 oz. polyethylene	10 ml - 20% H_2SO_4/1 at 4ºC	Digestion to convert all phosphorus forms to orthophosphate followed by determination using ascorbic acid reduction method using Technicon Auto-Analyzer (3, p. 256).	mg/1 P	0.01 mg/1	Regional IEPA lab	
Total Dissolved Phosphorus (TDP)	1 oz. polyethylene	10 ml - 20% H_2SO_4/1 at 4ºC	Field filtration followed by TP analysis as above.	mgl/ P	0.01 mg/1	Regional IEPA lab	0.05 mg/1
Fecal Coliform	6 oz. glass	1 ml - 10% $NA_2S_2O_3$/1	Filtration of sample through 0.45u membrance filter followed by incubation for 24 hrs. at 44.5ºC on pad containing M-FC culture media (6, p. 937).	# organisms per/100 ml	1/100 ml	Regional IEPA lab	200/100 ml
Total Mercury	6 oz. glass	20 ml - 25% K_2CR_2O7 in 50% HNO_8/1	Digestion with H_2SO_4 and potassium persulfate to convert all forms to inorganic HG followed by stannous chloride reduction step to convert all inorganic Hg to metalic Hg, then measurement by cold vapor atomic absorption (3, p. 127).	mg/1 Hg	0.05 mg/1	Champaign IEPA lab	0.5 mg/1

Appendix B

Tolerance Classification

Enumeration and identification of aquatic macroinvertebrate organisms were accomplished in accordance with standard Agency techniques and taxonomic references (IEPA Field Methods Manual, Section B, 1979a). Organisms were identified to the lowest taxonomic level possible, consistent with available references and time constraints. Upon identification, all organisms collected were assigned a tolerance status in accordance with known environmental requirements, current scientific literature and/or previous field experience. The four tolerance status categories for aquatic macroinvertebrates found in Illinois water are defined as:

INTOLERANT: Organisms whose life cycle is dependent upon a narrow range of environmental conditions. They are rarely found in areas of organic enrichment and are replaced by more tolerant species upon degradation of their environment.

MODERATE: Organisms which lack the extreme sensitivity to environmental stress displayed by intolerant species but cannot adapt to severe environmental degradation. Such organisms increase in abundance with slight to moderate levels of organic enrichment.

FACULTATIVE: Organisms which display the ability to survive over a wide range of environmental conditions and possess a greater degree of tolerance to adverse conditions than either intolerant or moderate species. The facultative tolerance status also includes all organisms which depend upon surface air for respiration.

TOLERANT: Organisms which not only have the ability to survive over a wide range of environmental extremes but are generally capable of thriving in water of extremely poor quality and even anaerobic conditions. Such organisms are often found in great abundance in areas of organic pollution.

Appendix C

Stream Classification

Each biological sampling station was assigned a classification based upon the abundance of intolerant organisms present. The classifications presently used by the Illinois Environmental Protection Agency to evaluate lotic (stream) environments are:

1. Balanced Environment: Intolerant organisms are many in number and species, or more in numbers than other forms present.

   Intolerant present 40% — Moderate, Facultative and Tolerant usually present 50%

2. Unbalanced Environment: Intolerant organisms are less in number than other forms combined, but combined with moderate forms, they usually outnumber tolerant forms.

   Intolerant present 50% but 10% — Moderate, Facultative and Tolerant usually present 50%

3. Semi-polluted Environment: Intolerant organisms are few or may not be present. Moderate and/or facultative organisms present.

   Intolerant present 10% — Moderate, Facultative and Tolerant usually present 90%

4. Polluted Environment: Intolerant organisms absent, only tolerant organisms present or no organisms present.

   Tolerant present 100%

5. Natural or artificial bare area.

It should be noted that aquatic communities cannot always be placed into neatly defined stream classifications to reflect pollutional conditions. Stream classifications as used in this report are intended to aid those persons not having sufficient time or training to interpret raw macroinvertebrate data. Differences in stream quality found in this study not adequately defined by stream classifications are discussed in terms of degradation or changes in stream quality.

TED:dks:sp/4537c, 1-116

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                                        S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                          27
                                                                                               20:03 WEDNESDAY, AUGUST 25, 1982
VARIABLE    N        MEAN        STANDARD       MINIMUM        MAXIMUM      STD ERROR          SUM       VARIANCE         C.V.
                                 DEVIATION       VALUE          VALUE        OF MEAN
--------------------------------------------------------- SITE=10 ---------------------------------------------------------------
RUNNO       9     5.00000000    2.73861279    1.00000000    9.00000000    0.91287093    45.0000000      7.500000       54.772
DAY         9    14.22222222   10.04711125    3.00000000   30.00000000    3.34903708   128.0000000    100.944444       70.644
YEAR        9    81.22222222    0.44095855   81.00000000   82.00000000    0.14698618   731.0000000      0.194444        0.543
FECAL       0      .             .             .             .             .             .              .                .
PHYTO       0      .             .             .             .             .             .              .                .
CHLORAC     0      .             .             .             .             .             .              .                .
CHLORAU     0      .             .             .             .             .             .              .                .
CHLORBU     0      .             .             .             .             .             .              .                .
CHLORCU     0      .             .             .             .             .             .              .                .
PHEOPHY     0      .             .             .             .             .             .              .                .
SECCHI2X    0      .             .             .             .             .             .              .                .
DEPTH       9    23.94444444    3.32080981   21.00000000   28.00000000    1.10693660   215.5000000     11.027778       13.869
PH          8     7.12500000    0.37701838    6.70000000    7.80000000    0.13329613    57.0000000      0.142143        5.291
COND        8   240.75000000   40.79478258  197.00000000  316.00000000   14.42313370  1926.0000000   1664.214286       16.945
TALK        8    66.25000000   14.82035280   40.00000000   90.00000000    5.23978598   530.0000000    219.642857       22.370
H2OTEMP     9    14.46666667    5.14611504    5.10000000   20.20000000    1.71537168   130.2000000     26.482500       35.572
DO          9     5.71111111    4.71631330    0.00000000   12.80000000    1.57210443    51.4000000     22.243611       82.581
NITRATE     8     0.53750000    0.45786773    0.00500000    1.20000000    0.16188069     4.3000000      0.209643       85.185
AMMONIA     8     0.54375000    0.55262846    0.02000000    1.30000000    0.19538367     4.3500000      0.305398      101.633
TKJELDN     8     1.45000000    0.80178373    0.50000000    2.40000000    0.28347335    11.6000000      0.642857       55.295
TOTP        8     0.25150000    0.21516638    0.05000000    0.62300000    0.07607280     2.0120000      0.046297       85.553
DISSP       8     0.14575000    0.19844665    0.02000000    0.59600000    0.07016148     1.1660000      0.039381      136.156
TSS         8    39.75000000   21.72391704   17.00000000   80.00000000    7.68056453   318.0000000    471.928571       54.651
VSS         8    11.87500000    7.01910658    0.00000000   21.00000000    2.48162693    95.0000000     49.267857       59.108
TURBID      8    48.25000000   45.66571380   14.00000000  140.00000000   16.14526689   386.0000000   2085.357143       94.644
COD         7    21.71428571    5.40722621   15.00000000   30.00000000    2.04373940   152.0000000     29.238095       24.902
LTURBID     8     1.53472779    0.37242052    1.14612804    2.14612804    0.13167054    12.2778224      0.138697       24.266
SECCHI      0      .             .             .             .             .             .              .                .
LSECCHI     0      .             .             .             .             .             .              .                .
NLSECCHI    0      .             .             .             .             .             .              .                .
TSISD       0      .             .             .             .             .             .              .                .
TSICHLOR    0      .             .             .             .             .             .              .                .
TP          8   251.50000000  215.16638080   50.00000000  623.00000000   76.07280348  2012.0000000  46296.571429       85.553
TSITP       8    78.71950115   13.46198946   60.58893689   96.98125852    4.75953202   629.7560092    181.225150       17.101
PERIOD      9     1.66666667    0.70710678    1.00000000    3.00000000    0.23570226    15.0000000      0.500000       42.426
CODEDATE    9    10.66666667    3.94301449    5.65625000   16.84375000    1.31433816    96.0000000     15.547363       36.966
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                                S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                            26
                                                                                           20:03 WEDNESDAY, AUGUST 25, 1982
VARIABLE      N          MEAN        STANDARD        MINIMUM         MAXIMUM       STD ERROR           SUM        VARIANCE        C.V.
                                    DEVIATION          VALUE           VALUE         OF MEAN

---------------------------------------------------------------- SITE=9 ----------------------------------------------------------------

RUNNO         5    7.00000000      1.58113883      5.00000000      9.00000000      0.70710678     35.0000000        2.500000      22.588
DAY           5   11.20000000      9.03880523      5.00000000     27.00000000      4.04227659     56.0000000       81.700000      80.704
YEAR          5   81.40000000      0.54772256     81.00000000     82.00000000      0.24494897    407.0000000        0.300000       0.673
FECAL         4  160.00000000    230.36203391      0.00000000    500.00000000    115.18101695    640.0000000    53066.666667     143.976
PHYTO         0             .               .               .               .               .              .               .           .
CHLORAC       3   36.02666667      7.27421703     27.99000000     42.16000000      4.19977116    108.0800000       52.914233      20.191
CHLORAU       3   43.60666667      7.37253236     35.21000000     49.02000000      4.25653354    130.8200000       54.354233      16.907
CHLORBU       3    3.87000000      0.90266273      2.83000000      4.45000000      0.52115257     11.6100000        0.814800      23.325
CHLORCU       3    5.56000000      5.88867086      1.30000000     12.28000000      3.39994118     16.6800000       34.678800     105.915
PHEOPHY       3   12.33666667      1.67482337     10.83000000     14.14000000      0.96695973     37.0100000        2.805033      13.576
SECCHI2X      5   13.20000000     10.05982107      2.00000000     28.00000000      4.49888875     66.0000000      101.200000      76.211
DEPTH         5    4.60000000      0.41833001      4.00000000      5.00000000      0.18708287     23.0000000        0.175000       9.094
PH            5    7.30000000      0.86602540      6.60000000      8.50000000      0.38729833     36.5000000        0.750000      11.863
COND          5  276.00000000     81.32650245    215.00000000    419.00000000     36.37031757   1380.0000000     6614.000000      29.466
TALK          5   60.00000000     12.74754878     40.00000000     70.00000000      5.70087713    300.0000000      162.500000      21.246
H2OTEMP       4   13.82500000      6.81242737      3.80000000     18.90000000      3.40621368     55.3000000       46.409167      49.276
DO            4    8.90000000      2.80356915      6.70000000     13.00000000      1.40178458     35.6000000        7.860000      31.501
NITRATE       5    0.67800000      0.72105478      0.05000000      1.60000000      0.32246550      3.3900000        0.519920     106.350
AMMONIA       5    0.36600000      0.32569925      0.05000000      0.84000000      0.14565713      1.8300000        0.106080      88.989
TKJELDN       5    2.26000000      1.36674797      1.20000000      4.60000000      0.61122827     11.3000000        1.868000      60.476
TOTP          5    0.30420000      0.28075648      0.09000000      0.79000000      0.12555811      1.5210000        0.078824      92.293
DISSP         5    0.06080000      0.06380596      0.01000000      0.17000000      0.02853489      0.3040000        0.004071     104.944
TSS           5  178.00000000    253.44131471     35.00000000    630.00000000    113.34240160    890.0000000    64232.500000     142.383
VSS           5   36.80000000     33.11646116     15.00000000     95.00000000     14.81013167    184.0000000     1096.700000      89.990
TURBID        5  161.64000000    249.42523529      8.20000000    600.00000000    111.54635628    808.2000000    62212.948000     154.309
COD           5   47.20000000     35.30863917     28.00000000    110.00000000     15.79050348    236.0000000     1246.700000      74.806
LTURBID       5    1.77621806      0.70478069      0.91381385      2.77815125      0.31518751      8.8810903        0.496716      39.679
SECCHI        5    0.16666667      0.12701794      0.02525253      0.35353535      0.05680415      0.8333333        0.016134      76.211
LSECCHI       5   -0.92340772      0.44656984     -1.59769519     -0.45156715      0.19971210     -4.6170386        0.199425     -48.361
NLSECCHI      5   -2.12622486      1.02826505     -3.67882912     -1.03977179      0.45985411    -10.6311243        1.057329     -48.361
TSISD         5   90.67494056     14.83472882     75.00073603    113.07428525      6.63429241    453.3747028      220.069179      16.360
TSICHLOR      3   65.58881719      2.08617787     63.25553032     67.27408131      1.20445536    196.7664516        4.352138       3.181
TP            5  304.20000000    280.75647811     90.00000000    790.00000000    125.55811403   1521.0000000    78824.200000      92.293
TSITP         5   82.56266520     11.64578685     69.06890596    100.40746342      5.20815421    412.8133260      135.624351      14.105
PERIOD        5    1.80000000      0.83666003      1.00000000      3.00000000      0.37416574      9.0000000        0.700000      46.481
CODEDATE      5   13.35000000      3.02103627     10.18750000     16.84375000      1.35104849     66.7500000        9.126660      22.629
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                                    S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                          25
                                                                                               20:03 WEDNESDAY, AUGUST 25, 1982

VARIABLE         N          MEAN         STANDARD        MINIMUM          MAXIMUM       STD ERROR          SUM        VARIANCE          C.V.
                                        DEVIATION          VALUE            VALUE         OF MEAN

--------------------------------------------------------------------- SITE=8 ---------------------------------------------------------------------

RUNNO            9    5.00000000       2.73861279     1.00000000       9.00000000      0.91287093     45.0000000       7.500000        54.772
DAY              9   14.22222222      10.04711125     3.00000000      30.00000000      3.34903708    128.0000000     100.944444        70.544
YEAR             9   81.22222222       0.44095855    81.00000000      82.00000000      0.14698618    731.0000000       0.194444         0.543
FECAL            6  229.66666667     311.92413608     0.00000000     800.00000000    127.34249531   1378.0000000   97296.666667       135.815
PHYTO            0             .                .              .                .               .              .              .             .
CHLORAC          7   19.47000000      12.30164081     9.99000000      45.00000000      4.64958319    136.2900000     151.330367        63.183
CHLORAU          7   23.83142857      11.56094493    14.35000000      47.58000000      4.36962646    166.8200000     133.655448        48.511
CHLORBU          7    2.94285714       2.37827468     0.75000000       7.55000000      0.89890334     20.6000000       5.656190        80.815
CHLORCU          7    1.95857143       0.74324578     0.95000000       3.26000000      0.28092050     13.7100000       0.552414        37.948
PHEOPHY          7    7.24714286       5.60043366     2.67000000      18.77000000      2.11676496     50.7300000      31.364857        77.279
SECCHI2X         9   23.77777778      14.77986618     2.00000000      52.00000000      4.92662206    214.0000000     218.444444        62.158
DEPTH            9    8.44444444       2.05311417     3.00000000       9.50000000      0.68437139     76.0000000       4.215278        24.313
PH               9    7.78888889       0.71141487     6.60000000       8.70000000      0.23713829     70.1000000       0.506111         9.134
COND             9  216.22222222      19.40217628   195.00000000     250.00000000      6.46739209   1946.0000000     376.444444         8.973
TALK             9   57.77777778      12.01850425    40.00000000      75.00000000      4.00616808    520.0000000     144.444444        20.801
H2OTEMP          8   20.12500000       7.98512009     4.80000000      28.20000000      2.82316628    161.0000000      63.762143        39.678
DO               8    9.22500000       2.63208228     5.80000000      13.80000000      0.93058162     73.8000000       6.927857        28.532
NITRATE          9    0.46833333       0.45635786     0.00500000       1.30000000      0.15211929      4.2150000       0.208262        97.443
AMMONIA          9    0.21944444       0.31470665     0.00500000       0.82000000      0.10490222      1.9750000       0.099040       143.411
TKJELDN          9    1.34444444       0.86906719     0.50000000       3.10000000      0.28968906     12.1000000       0.755278        64.641
TOTP             9    0.15411111       0.13324549     0.04000000       0.40000000      0.04441516      1.3870000       0.017754        86.461
DISSP            9    0.05122222       0.06123067     0.00900000       0.21000000      0.02041022      0.4610000       0.003749       119.539
TSS              9   50.33333333      41.44574767    20.00000000     140.00000000     13.81524922    453.0000000    1717.750000        82.343
VSS              9   13.33333333       7.69740216     5.00000000      30.00000000      2.56580072    120.0000000      59.250000        57.731
TURBID           9   59.18888889      82.23014114     7.70000000     225.00000000     27.41004705    532.7000000    6761.796111       138.928
COD              9   25.44444444      10.71343912    13.00000000      47.00000000      3.57114637    229.0000000     114.777778        42.105
LTURBID          9    1.46902835       0.50049688     0.88649073       2.35218252      0.16683229     13.2212552       0.250497        34.070
SECCHI           9    0.30022447       0.18661447     0.02525253       0.65656566      0.06220482      2.7020202       0.034825        62.158
LSECCHI          9   -0.66637470       0.46200137    -1.59769519      -0.18272184      0.15400046     -5.9973723       0.213445       -69.331
NLSECCHI         9   -1.53438445       1.06379746    -3.67882912      -0.42073258      0.35459915    -13.8094600       1.131665       -69.331
TSISD            9   82.13648831      15.34735324    66.06988807     113.07428525      5.11578441    739.2283948     235.541252        18.685
TSICHLOR         7   58.36360458       5.23918516    53.14831698      67.91362222      1.98022586    408.5452321      27.449061         8.977
TP               9  154.11111111     133.24549190    40.00000000     400.00000000     44.41516397   1387.0000000   17754.361111        86.461
TSITP            9   72.44470574      11.67326495    57.36965594      90.58893689      3.89108832    652.0023516     136.265115        16.113
PERIOD           9    1.66666667       0.70710678     1.00000000       3.00000000      0.23570226     15.0000000       0.500000        42.426
CODEDATE         9   10.66666667       3.94301449     5.65625000      16.84375000      1.31433816     96.0000000      15.547363        36.956
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                                   S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                              26
                                                                                                       20:03 WEDNESDAY, AUGUST 25, 1982
VARIABLE     N         MEAN        STANDARD       MINIMUM        MAXIMUM      STD ERROR          SUM         VARIANCE           C.V.
                                   DEVIATION       VALUE          VALUE        OF MEAN

------------------------------------------------------------------- SITE=7 ----------------------------------------------------------------

RUNNO        9    5.00000000     2.73861279     1.00000000     9.00000000    0.91287093     45.0000000       7.500000         54.772
DAY          9   14.22222222    10.04711125     3.00000000    30.00000000    3.34903708    128.0000000     100.944444         70.644
YEAR         9   81.22222222     0.44095855    81.00000000    82.00000000    0.14698618    731.0000000       0.194444          0.543
FECAL        5  306.40000000   295.44001083    12.00000000   800.00000000  132.12478950   1532.0000000   87284.800000         96.423
PHYTO        0     .              .              .              .             .              .              .                .
CHLORAC      7   20.72142857    18.02770685     3.73000000    57.85000000    6.81383272    145.0500000     324.998214         87.000
CHLORAU      7   24.99571429    18.35576100     4.93000000    61.58000000    6.93782553    174.9700000     336.933962         73.436
CHLORBU      7    3.45285714     3.68099948     0.15000000    11.10000000    1.39128703     24.1700000      13.549757        106.607
CHLORCU      7    2.49000000     1.79333024     0.09000000     4.87000000    0.67781512     17.4300000       3.216033         72.021
PHEOPHY      7    7.15714286     4.33845101     1.90000000    14.84000000    1.63978035     50.1000000      18.822157         60.617
SECCHI2X     9   23.77777778    14.40293180     2.00000000    52.00000000    4.80097727    214.0000000     207.444444         60.573
DEPTH        9    6.44444444     0.98248551     6.00000000     9.00000000    0.32749517     58.0000000       0.965278         15.245
PH           9    7.66666667     0.65574385     6.70000000     8.30000000    0.21858128     69.0000000       0.430000          8.553
COND         9  216.88888889    22.29598868   185.00000000   255.00000000    7.43199623   1952.0000000     497.111111         10.280
TALK         9   58.33333333    14.57737974    40.00000000    90.00000000    4.85912658    525.0000000     212.500000         24.990
H2OTEMP      8   20.25000000     7.68913891     5.10000000    28.00000000    2.71852113    162.0000000      59.122857         37.971
DO           8    9.27500000     2.56222560     6.50000000    13.50000000    0.90588355     74.2000000       6.565000         27.625
NITRATE      8    0.36687500     0.36479875     0.00500000     1.10000000    0.12897583      2.9350000       0.133078         99.434
AMMONIA      9    0.24555556     0.32206797     0.01000000     0.90000000    0.10735599      2.2100000       0.103728        131.159
TKJELDN      9    1.38888889     0.69000805     0.70000000     2.90000000    0.23000268     12.5000000       0.476111         49.681
TOTP         9    0.15777778     0.13058501     0.03000000     0.40000000    0.04352834      1.4200000       0.017052         82.765
DISSP        9    0.04644444     0.06213516     0.00900000     0.21000000    0.02071172      0.4180000       0.003861        133.784
TSS          9   47.55555556    42.36481769    12.00000000   150.00000000   14.12160590    428.0000000    1794.777778         89.085
VSS          9   14.00000000     9.47364766     0.00000000    30.00000000    3.15788255    126.0000000      89.750000         67.669
TURBID       9   56.50000000    76.55145328     7.50000000   210.00000000   25.51715109    508.5000000    5860.125000        135.489
COD          8   23.75000000     6.31890587    16.00000000    35.00000000    2.23407060    190.0000000      39.928571         26.606
LTURBID      9    1.46547572     0.48795692     0.87506126     2.32221929    0.16265231     13.1892815       0.238102         33.297
SECCHI       9    0.30022447     0.18185520     0.02525253     0.65656566    0.06061840      2.7020202       0.033071         60.573
LSECCHI      9   -0.65062815     0.43354656    -1.59769519    -0.18272184    0.14451552     -5.8556534       0.187963        -66.635
NLSECCHI     9   -1.49812668     0.99827784    -3.67882912    -0.42073258    0.33275928    -13.4831401       0.996559        -66.635
TSISD        9   81.61339936    14.40210489    66.06988807   113.07428525    4.80070163    734.5205943     207.420625         17.647
TSICHLOR     7   57.33495367     8.45143336    43.48341545    70.37788753    3.19434156    401.3446757      71.426726         14.740
TP           9  157.77777778   130.58500850    30.00000000   400.00000000   43.52833617   1420.0000000   17052.444444         82.765
TSITP        9   72.83993525    12.00499213    53.21928095    90.58893689    4.00166404    655.5594173     144.119836         16.491
PERIOD       9    1.66666667     0.70710678     1.00000000     3.00000000    0.23570226     15.0000000       0.500000         42.425
CODEDATE     9   10.66666667     3.94301449     5.65625000    16.84375000    1.31433816     96.0000000      15.547363         36.966
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                                  S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                         27
                                                                                                  20:03 WEDNESDAY, AUGUST 25, 1982

VARIABLE         N        MEAN         STANDARD        MINIMUM        MAXIMUM       STD ERROR          SUM        VARIANCE       C.V.
                                       DEVIATION        VALUE          VALUE         OF MEAN

--------------------------------------------------------------- SITE=6 ----------------------------------------------------------------

RUNNO            9     5.00000000     2.73861279     1.00000000     9.00000000    0.91287093    45.0000000       7.500000     54.772
DAY              9    14.22222222    10.04711125     3.00000000    30.00000000    3.34903705   129.0000000     100.944444     70.646
YEAR             9    81.22222222     0.44095855    81.00000000    82.00000000    0.14698618   731.0000000       0.194444      0.543
FECAL            6   178.33333333   190.93628955    10.00000000   500.00000000   77.94941380  1070.0000000   36456.666667    107.067
PHYTO            0              .              .              .              .             .             .              .          .
CHLORAC          7    19.77857143    11.91339803     5.47000000    43.31000000    4.50283743   138.4500000     141.928816     60.234
CHLORAU          7    23.68000000    12.52643738    17.62000000    47.59000000    4.73454830   165.7600000     156.911633     52.899
CHLORBU          7     2.77142857     1.64299958     0.66000000     5.56000000    0.62099547    19.4000000       2.699448     59.293
CHLORCU          7     3.26142857     2.02222179     1.51000000     7.05000000    0.76432799    22.8300000       4.089381     62.004
PHEOPHY          7     6.45000000     4.30582938     2.31000000    13.55000000    1.62745053    45.1500000      18.540167     66.757
SECCHI2X         9    24.22222222    14.71205099     2.00000000    52.00000000    4.90401700   218.0000000     216.444444     60.739
DEPTH            9    11.61111111     0.33333333    11.00000000    12.00000000    0.11111111   104.5000000       0.111111      2.871
PH               9     7.71111111     0.58190301     6.60000000     8.30000000    0.19396767    69.4000000       0.338611      7.546
COND             9   215.77777778    22.76937514   180.00000000   255.00000000    7.58979171  1942.0000000     518.444444     10.552
TALK             9    61.66666667    14.57737974    40.00000000    90.00000000    4.85912658   555.0000000     212.500000     23.639
H2OTEMP          8    19.97500000     7.91503093     4.70000000    28.50000000    2.79839921   159.8000000      62.647857     39.625
DO               8     9.43750000     2.0880[illegible]54     7.40000000    13.30000000    0.73822603    75.5000000       4.359821     22.125
NITRATE          9     0.44833333     0.44481738     0.00500000     1.30000000    0.14827246     4.0350000       0.197862     99.215
AMMONIA          9     0.24000000     0.35703641     0.02000000     1.00000000    0.11901214     2.1600000       0.127475    148.765
TKJELDN          9     1.33333333     0.74161985     0.70000000     2.90000000    0.24720662    12.0000000       0.550000     55.621
TOTP             9     0.15288889     0.14071731     0.03000000     0.43000000    0.04690577     1.3760000       0.019801     92.039
DISSP            9     0.04666667     0.06601326     0.00400000     0.22000000    0.02200442     0.4200000       0.004358    141.457
TSS              9    54.44444444    48.01591171    14.00000000   160.00000000   [illegible].00530390   490.0000000    2305.527778     88.192
VSS              9    14.88888889    11.10680472     3.00000000    38.00000000    3.70226824   134.0000000     123.361111     74.595
TURBID           9    55.91111111    81.62132755     6.40000000   225.00000000   27.20710918   503.2000000    6662.041111    145.994
COD              9    26.00000000    11.11305539    17.00000000    50.00000000    3.70435180   234.0000000     123.500000     42.743
LTURBID          9     1.40297658     0.53794861     0.80617997     2.35218252    0.17931620    12.6267992       0.289389     38.343
SECCHI           9     0.30583614     0.18575822     0.02525253     0.65656566    0.06191961     2.7525253       0.034506     60.739
LSECCHI          9    -0.64547775     0.43848361    -1.59769519    -0.18272184    0.14616120    -5.8092997       0.192268    -67.932
NLSECCHI         9    -1.48626744     1.00964582    -3.67882912    -0.42073258    0.33654861   -13.3764069       1.019385    -67.932
TSISD            9    81.44230663    14.56611014    66.06988807   113.07428525    4.85537005   732.9807597     212.171566     17.895
TSICHLOR         7    58.31521931     6.15076617    47.23949883    67.53809338    2.32477109   408.2065351      37.831926     10.547
TP               9   152.88888889   140.71730921    30.00000000   430.00000000   46.90576974  1376.0000000   19801.361111     92.039
TSITP            9    71.90977529    12.24173665    53.21928095    91.63230369    4.08057888   647.1879776     149.860115     17.024
PERIOD           9     1.66666667     0.70710678     1.00000000     3.00000000    0.23570226    15.0000000       0.500000     42.425
CODEDATE         9    10.66666667     3.94301449     5.65625000    16.84375000    1.31433816    96.0000000      15.547363     36.966
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                                   S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                              22
                                                                                                     20:03 WEDNESDAY, AUGUST 25, 1982
VARIABLE   .  N         MEAN        STANDARD       MINIMUM        MAXIMUM      STD ERROR          SUM       VARIANCE         C.V.
                                    DEVIATION        VALUE          VALUE        OF MEAN

------------------------------------------------------------ SITE=5 ------------------------------------------------------------------

RUNNO         9     5.00000000     2.73861279     1.00000000     9.00000000     0.91287093    45.0000000       7.500000       54.772
DAY           9    14.22222222    10.04711125     3.00000000    30.00000000     3.34903708   128.0000000     100.944444       70.644
YEAR          9    81.22222222     0.44095855    81.00000000    82.00000000     0.14698618   731.0000000       0.194444        0.543
FECAL         6    73.33333333   150.68731422     0.00000000   380.00000000    61.51783542   440.0000000   22706.666667      205.483
PHYTO         0              .              .              .              .              .             .              .            .
CHLORAC       7    15.21857143     9.09004846     5.77000000    26.67000000     3.43571537   106.5300000      82.629981       59.730
CHLORAU       7    18.47285714     9.59900640     7.49000000    29.92000000     3.62808339   129.3100000      92.140924       51.963
CHLORBU       7     1.85857143     1.72698609     0.29000000     5.19000000     0.65273939    13.0100000       2.982481       92.920
CHLORCU       7     2.47571429     1.53981446     1.07000000     5.53000000     0.58199516    17.3300000       2.371029       62.197
PHEOPHY       7     5.33428571     2.44837264     2.56000000     8.80000000     0.92539787    37.3400000       5.994529       45.899
SECCHI2X      9    26.66666667    15.16575089     2.00000000    48.00000000     5.05525030   240.0000000     230.000000       56.872
DEPTH         9    14.22222222     0.79494933    13.00000000    15.00000000     0.26498311   128.0000000       0.631944        5.589
PH            9     7.65555556     0.59395099     6.70000000     8.50000000     0.19798366    68.9000000       0.352778        7.759
COND          9   214.77777778    22.59854961   180.00000000   250.00000000     7.53284987  1933.0000000     510.694444       10.522
TALK          9    59.44444444    15.70120307    35.00000000    90.00000000     5.23373436   535.0000000     246.527778       26.413
H2OTEMP       8    19.27500000     7.67179435     5.00000000    27.50000000     2.71238890   154.2000000      58.856429       39.802
DO            8     9.02500000     1.68332155     7.10000000    11.90000000     0.59514604    72.2000000       2.833571       18.652
NITRATE       9     0.49722222     0.45602296     0.00500000     1.30000000     0.15200765     4.4750000       0.207957       91.714
AMMONIA       9     0.26833333     0.32021477     0.00500000     0.89000000     0.10673926     2.4150000       0.102537      119.335
TKJELDN       9     1.30000000     0.78581168     0.60000000     2.90000000     0.25193723    11.7000000       0.617500       60.447
TOTP          9     0.15155556     0.13786688     0.04000000     0.42000000     0.04595563     1.3640000       0.019007       90.969
DISSP         9     0.05433333     0.06176973     0.01000000     0.21000000     0.02058991     0.4890000       0.003815      113.687
TSS           9    49.66666667    56.24055476    15.00000000   190.00000000    18.74685159   447.0000000    3163.000000      113.236
VSS           9    11.22222222     9.13479307     3.00000000    32.00000000     3.04493102   101.0000000      83.444444       81.390
TURBID        9    57.52222222    83.98365582     7.70000000   235.00000000    27.99455194   517.7000000    7053.254444      146.002
COD           8    22.37500000     7.68927825    15.00000000    38.00000000     2.71857040   179.0000000      59.125000       34.365
LTURBID       9     1.42334750     0.52523799     0.88649073     2.37106786     0.17507933    12.8101275       0.275875       36.902
SECCHI        9     0.33670034     0.19148675     0.02525253     0.60606061     0.06382892     3.0303030       0.036667       56.872
LSECCHI       9    -0.60806158     0.45543438    -1.59769519    -0.21748394     0.15181146    -5.4725542       0.207420      -74.899
NLSECCHI      9    -1.40011352     1.04867641    -3.67882912    -0.50077524     0.34955880   -12.6010217       1.099722      -74.899
TSISD         9    80.19936830    15.12920253    67.22466024   113.07428525     5.04306751   721.7943147     228.892769       18.864
TSICHLOR      7    55.47092202     6.69541362    47.76330613    62.78161342     2.53062848   388.2964541      44.828563       12.070
TP            9   151.55555556   137.86688427    40.00000000   420.00000000    45.95562809  1364.0000000   19007.277778       90.968
TSITP         9    71.93485013    11.84663400    57.36965594    91.29283017     3.94887900   647.4136512     140.342737       16.469
PERIOD        9     1.66666667     0.70710678     1.00000000     3.00000000     0.23570226    15.0000000       0.500000       42.426
CODEDATE      9    10.66666667     3.94301449     5.65625000    16.84375000     1.31433816    96.0000000      15.547363       36.966
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                                S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                     21
                                                                                          20:03 WEDNESDAY, AUGUST 25, 1982

VARIABLE      N         MEAN        STANDARD        MINIMUM         MAXIMUM      STD ERROR          SUM        VARIANCE         C.V.
                                   DEVIATION          VALUE           VALUE        OF MEAN

------------------------------------------------------------- SITE=4 ---------------------------------------------------------------

RUNNO         9     5.00000000     2.73861279     1.00000000      9.00000000    0.91287093   45.0000000       7.500000       54.772
DAY           9    14.22222222    10.04711125     3.00000000     30.00000000    3.34903708  128.0000000     100.944444       70.644
YEAR          9    81.22222222     0.44095855    81.00000000     82.00000000    0.14698618  731.0000000       0.194444        0.543
FECAL         6    23.33333333    39.04185788     0.00000000    100.00000000   15.93877174  140.0000000    1524.266667      167.322
PHYTO         0              .              .              .               .             .            .              .            .
CHLORAC       7    12.75571429     8.55404555     4.42000000     26.84000000    3.23312532   89.2900000      73.171695       67.060
CHLORAU       7    15.15857143     9.14426492     5.51000000     28.68000000    3.45620727  106.1100000      83.617581       60.324
CHLORBU       7     1.64714286     1.67366578     0.00000000      4.69000000    0.63258620   11.5300000       2.801157      101.610
CHLORCU       7     2.77714286     4.22134542     0.18000000     12.07000000    1.59551860   19.4400000      17.819757      152.003
PHEOPHY       7     3.95000000     3.84937224     0.60000000     10.95000000    1.45492595   27.6500000      14.817567       97.452
SECCHI2X      9    24.44444444    14.31005862     2.00000000     46.00000000    4.77001954  220.0000000     204.777778       58.541
DEPTH         9    17.88888889     2.14734979    15.00000000     20.50000000    0.71578326  161.0000000       4.611111       12.004
PH            8     7.71250000     0.69165950     6.60000000      8.70000000    0.24453856   61.7000000       0.478393        8.968
COND          9   215.88888889    21.57802380   185.00000000    250.00000000    7.19267460 1943.0000000     465.611111        9.995
TALK          9    56.66666667    10.00000000    40.00000000     70.00000000    3.33333333  510.0000000     100.000000       17.647
H2OTEMP       8    19.48750000     7.74198895     5.30000000     28.00000000    2.73720644  155.9000000      59.938393       39.728
DO            8     8.62500000     2.49041018     5.60000000     12.60000000    0.88049296   69.0000000       6.202143       28.874
NITRATE       9     0.54277778     0.42932440     0.00500000      1.30000000    0.14310813    4.8850000       0.184319       79.098
AMMONIA       9     0.33222222     0.63534986     0.01000000      1.90000000    0.21178329    2.9900000       0.403669      191.262
TKJELDN       9     1.35555556     0.90292734     0.60000000      3.10000000    0.30097578   12.2000000       0.815278       66.609
TOTP          9     0.15444444     0.12574191     0.05400000      0.35000000    0.04191397    1.3900000       0.015811       81.416
DISSP         9     0.05344444     0.06039684     0.00900000      0.21000000    0.02013228    0.4810000       0.003648      113.009
TSS           9    39.44444444    34.02245990    10.00000000    110.00000000   11.34081997  355.0000000    1157.527778       86.254
VSS           9    15.77777778    13.20774184     1.00000000     46.00000000    4.40258061  142.0000000     174.444444       83.711
TURBID        9    50.34444444    66.82770966     8.10000000    170.00000000   22.27590322  453.1000000    4465.942778      132.741
COD           8    23.37500000     9.84069539    14.00000000     43.00000000    3.47921122  187.0000000      96.839286       42.099
LTURBID       9     1.41646784     0.48983996     0.90848502      2.23044892    0.16327999   12.7482106       0.239943       34.582
SECCHI        9     0.30864198     0.18068256     0.02525253      0.58080808    0.06022752    2.7777778       0.032646       58.541
LSECCHI       9    -0.66226992     0.44193420    -1.59769519     -0.23596735    0.14731140   -5.7804293       0.195306      -66.730
MLSECCHI      9    -1.47888114     1.01759111    -3.67882912     -0.54333490    0.33919704  -13.3099303       1.035492      -68.808
TSISD         9    81.33574489    14.68073643    67.83866569    113.07428525    4.89357881  732.0217040     215.524022       18.050
TSICHLOR      7    53.54355861     6.86282052    45.14853648     62.84394795    2.59390234  374.8049103      47.098306       12.817
TP            9   154.44444444   125.74190939    54.00000000    350.00000000   41.91396980 1390.0000000   15811.027778       81.416
TSITP         9    72.78137474    11.20603421    61.69925001     88.66248611    3.73534474  655.0323727     125.575203       15.397
PERIOD        9     1.66666667     0.70710678     1.00000000      3.00000000    0.23570226   15.0000000       0.500000       42.426
CODEDATE      9    10.66666667     3.94301449     5.65625000     16.84375000    1.31433816   96.0000000      15.547363       36.966
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                                        S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                              20
                                                                                                        20:03 WEDNESDAY, AUGUST 25, 1982

VARIABLE       N          MEAN            STANDARD          MINIMUM          MAXIMUM       STD ERROR            SUM          VARIANCE          C.V.
                                          DEVIATION           VALUE            VALUE         OF MEAN

------------------------------------------------------------------ SITE=3 -----------------------------------------------------------------------------

RUNNO          9      5.00000000       2.73861279       1.00000000        9.0000000       0.9128709      45.0000000           7.500        54.772
DAY            9     14.22222222      10.04711125       3.00000000       30.0000000       3.3490371     128.0000000         100.944        70.644
YEAR           9     81.22222222       0.44095855      81.00000000       82.0000000       0.1469862     731.0000000           0.194         0.543
FECAL          6   1616.66666667    3622.11356347       0.00000000     9000.0000000    1478.7216702    9700.0000000    13119706.667       224.048
PHYTO          0               .                .                .                .               .               .               .             .
CHLORAC        7     18.36285714      11.63829128       1.45000000       31.6700000       4.3988606     128.5400000         135.450        63.380
CHLORAU        7     22.39857143      13.45703834       2.99000000       37.3100000       5.0862824     156.7900000         181.092        60.080
CHLORBU        7      1.75714286       1.50762191       0.30000000        4.2900000       0.5698275      12.3000000           2.273        85.800
CHLORCU        7      2.69857143       2.05289575       0.00000000        5.9300000       0.7759217      18.8900000           4.214        76.073
PHEOPHY        7      6.53142857       3.70522347       2.06000000       12.3700000       1.4004428      45.7200000          13.729        56.729
SECCHI2X       9     13.55555556       7.92324288       4.00000000       30.0000000       2.6410810     122.0000000          62.778        58.450
DEPTH          9      2.44444444       0.68211273       2.00000000        4.0000000       0.2273709      22.0000000           0.465        27.905
PH             9      7.24444444       0.69482212       6.40000000        8.1000000       0.2316074      65.2000000           0.483         9.591
COND           9    247.88888889      83.91877687     120.00000000      394.0000000      27.9729256    2231.0000000        7042.361        33.853
TALK           9     56.66666667      16.20185175      35.00000000       90.0000000       5.4006172     510.0000000         262.500        28.592
H2OTEMP        9     17.53333333       9.05317624       2.40000000       27.5000000       3.0177254     157.8000000          81.960        51.636
DO             9      7.88888889       2.68209081       2.60000000       12.5000000       0.8940303      71.0000000           7.194        33.998
NITRATE        9      0.64944444       0.87430131       0.00500000        2.7000000       0.2914338       5.8450000           0.764       134.623
AMMONIA        9      0.44333333       0.69061567       0.01000000        2.2000000       0.2302052       3.9900000           0.477       155.778
TKJELDN        9      2.01111111       1.05290603       0.90000000        4.2000000       0.3509687      18.1000000           1.109        52.354
TOTP           9      0.32277778       0.23472738       0.05800000        0.6640000       0.0782425       2.9050000           0.055        72.721
DISSP          9      0.12044444       0.12266837       0.02300000        0.3200000       0.0408895       1.0840000           0.015       101.846
TSS            9    114.00000000      89.35602946      19.00000000      270.0000000      29.7853432    1026.0000000        7984.500        78.382
VSS            9     23.11111111      14.48658383       1.00000000       44.0000000       4.8288613     208.0000000         209.861        62.682
TURBID         9     88.44444444      96.76144779      10.00000000      265.0000000      32.2538159     796.0000000        9362.778       109.404
COD            9     37.77777778      12.83333333      20.00000000       58.0000000       4.2777778     340.0000000         164.694        33.971
LTURBID        9      1.70211948       0.50701911       1.00000000        2.4232459       0.1690064      15.3190753           0.257        29.788
SECCHI         9      0.17115600       0.10004095       0.05050505        0.3787879       0.0333470       1.5404040           0.010        58.450
LSECCHI        9     -0.83947403       0.27922384      -1.29666519       -0.4216039       0.0930746      -7.5552663           0.078       -33.262
NLSECCHI       9     -1.93296039       0.64293665      -2.98568194       -0.9707789       0.2143122     -17.3966435           0.413       -33.262
TSISD          9     87.88672374       9.27561515      74.00537930      103.0742853       3.0918717     790.9805136          86.037        10.554
TSICHLOR       7     54.94946055      12.22658379      34.21418089       64.4673269       4.6212143     384.6462238         149.489        22.251
TP             9    322.77777778     234.72738324      58.00000000      664.0000000      78.2424611    2905.0000000       55096.944        72.721
TSITP          9     82.91690024      13.36861092      62.73018494       97.9007693       4.4562036     746.2521022         178.720        16.123
PERIOD         9      1.66666667       0.70710678       1.00000000        3.0000000       0.2357023      15.0000000           0.500        42.426
CODEDATE       9     10.66666667       3.94301449       5.65625000       16.8437500       1.3143382      96.0000000          15.547        36.966
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                                   S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                        19
                                                                                              20:03 WEDNESDAY, AUGUST 25, 1982
VARIABLE      N        MEAN        STANDARD        MINIMUM         MAXIMUM       STD ERROR          SUM         VARIANCE        C.V.
                                   DEVIATION        VALUE           VALUE         OF MEAN

-------------------------------------------------------------- SITE=2 -----------------------------------------------------------------

RUNNO         9     5.00000000    2.73861279    1.00000000      9.00000000    0.91287093    45.0000000       7.500000      54.772
DAY           9    14.22222222   10.04711125    3.00000000     30.00000000    3.34903709   128.0000000     100.944444      70.644
YEAR          9    81.22222222    0.44095855   81.00000000     82.00000000    0.14698618   731.0000000       0.194444       0.543
FECAL         5    42.40000000   88.19750563    0.00000000    200.00000000   39.44312361   212.0000000    7778.800000     208.013
PHYTO         0              .             .             .               .             .             .              .           .
CHLORAC       6    14.51500000   11.63756633    0.00000000     32.66000000    4.75101656    87.0900000     135.432950      80.176
CHLORAU       6    18.94000000   13.29141828    0.00000000     35.64000000    5.42619879   113.6400000     176.661800      70.176
CHLORBU       6     1.36833333    1.59701492    0.00000000      4.23000000    0.65197861     8.2100000       2.550457     116.712
CHLORCU       6     1.85500000    1.77296080    0.00000000      4.49000000    0.72380822    11.1300000       3.143390      95.577
PHEOPHY       6     7.21666667    8.60618072    0.00000000     24.10000000    3.51345857    43.3000000      74.066347     119.254
SECCHI2X      9    24.66666667   15.32970972    2.00000000     48.00000000    5.10990324   222.0000000     235.000000      62.147
DEPTH         9    11.94444444    0.52704628   11.50000000     13.00000000    0.17568209   107.5000000       0.277778       4.412
PH            9     7.38888889    0.71840874    6.20000000      8.30000000    0.23946958    66.5000000       0.516111       9.723
COND          9   214.33333333   34.92849839  154.00000000    264.00000000   11.64283280  1929.0000000    1220.000000      16.296
TALK          9    53.88888889   13.41123078   40.00000000     75.00000000    4.47041026   485.0000000     179.861111      24.887
H2OTEMP       9    17.57777778    7.93091700    4.80000000     26.50000000    2.64363900   158.2000000      62.899444      45.119
DO            9     8.44444444    2.68379913    5.00000000     13.70000000    0.89459971    76.0000000       7.202778      31.792
NITRATE       9     0.72277778    0.86716172    0.00500000      2.70000000    0.28905391     6.5050000       0.751969     119.975
AMMONIA       9     0.31000000    0.30651264    0.02000000      0.81000000    0.10217088     2.7900000       0.093950      98.875
TKJELDN       9     1.73333333    1.17686023    0.70000000      4.30000000    0.39228674    15.6000000       1.385000      67.896
TOTP          9     0.26566667    0.29133615    0.04000000      0.82000000    0.09711205     2.3910000       0.084877     109.662
DISSP         9     0.08477778    0.09989717    0.02000000      0.27400000    0.03329906     0.7630000       0.009979     117.834
TSS           9   108.11111111  148.08818694   13.00000000    430.00000000   49.36272898   973.0000000   21930.111111     136.978
VSS           9    22.66666667   22.82542442    2.00000000     65.00000000    7.60847481   204.0000000     521.000000     100.700
TURBID        9   118.43333333  178.18758374    6.90000000    530.00000000   59.39586125  1065.9000000   31750.815000     150.454
COD           9    37.11111111   29.77601570   18.00000000    110.00000000    9.92533857   334.0000000     886.611111      80.235
LTURBID       9     1.60256811    0.67718478    0.85884909      2.72427587    0.22572826    14.4231130       0.458579      42.256
SECCHI        9     0.31144781    0.19355694    0.02525253      0.60606061    0.06451898     2.8030303       0.037464      62.147
LSECCHI       9    -0.68438261    0.53108740   -1.59769519     -0.21748394    0.17702913    -6.1594417       0.282054     -77.601
MLSECCHI      9    -1.57584876    1.22287394   -3.67882912     -0.50077529    0.40762465   -14.1826386       1.495421     -77.601
TSISD         9    82.73469160   17.64234162   67.22466024    113.07628525    5.88079054   744.6122244     311.252218      21.324
TSICHLOR      5    57.20367368    5.91024659   49.61690003     64.76930079    2.64314263   286.0183684      34.931015      10.332
TP            9   265.66666667  291.33614606   40.00000000    820.00000000   97.11204869  2391.0000000   84876.750000     109.662
TSITP         9    76.91492002   15.78400524   57.36965594    100.94517599    5.26133508   692.2342802     249.134821      20.521
PERIOD        9     1.66666667    0.70710678    1.00000000      3.00000000    0.23570226    15.0000000       0.500000      42.426
CODEDATE      9    10.66666667    3.94301449    5.65625000     16.84375000    1.31433816    96.0000000      15.547363      36.966
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                                  S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                   18
                                                                                        20:03 WEDNESDAY, AUGUST 25, 1982

VARIABLE          N            MEAN       STANDARD        MINIMUM        MAXIMUM      STD ERROR            SUM       VARIANCE         C.V.
                                         DEVIATION          VALUE          VALUE        OF MEAN

--------------------------------------------------------- SITE=1 ---------------------------------------------------------------------

RUNNO           9      5.00000000     2.73861279     1.00000000     9.00000000     0.91287093     45.0000000      7.5000000       54.772
DAY             9     14.22222222    10.04711125     3.00000000    30.00000000     3.34903708    128.0000000    100.9444444       70.644
YEAR            9     81.22222222     0.44095855    81.00000000    82.00000000     0.14698618    731.0000000      0.1944444        0.543
FECAL           6     26.33333333    30.34248946     0.00000000    70.00000000    12.38726945    158.0000000    920.6666667      115.225
PHYTO           0
                       .              .              .              .              .              .              .                .
CHLORAC         7     12.41571429    12.02779400     1.47000000    30.18000000     4.54607882     86.9100000    144.6678286       96.876
CHLORAU         7     16.13285714    14.40175303     1.63000000    35.35000000     5.44335100    112.9300000    207.4104905       89.270
CHLORBU         7      1.76285714     2.05851657     0.00000000     5.92000000     0.77804613     12.3400000      4.2374905      116.772
CHLORCU         7      1.35428571     1.42683633     0.00000000     4.11000000     0.53929344      9.4800000      2.0358619      105.357
PHEOPHY         7      6.15000000     6.54232629     0.26000000    19.38000000     2.47276691     43.0500000     42.8020333      106.379
SECCHI2X        8     32.75000000    14.13961002    12.00000000    52.00000000     4.99910706    262.0000000    199.9285714       43.174
DEPTH           9     23.94444444     3.32080981    21.00000000    28.00000000     1.10693660    215.5000000     11.0277778       13.869
PH              8      7.30000000     0.36253079     6.70000000     7.90000000     0.12817399     58.4000000      0.1314286        4.966
COND            8    216.75000000    17.37609195   193.00000000   248.00000000     6.14337622   1734.0000000    301.9285714        8.017
TALK            8     60.62500000    19.89930006    30.00000000    85.00000000     7.03546501    485.0000000    395.9821429       32.824
H2OTEMP         9     17.35555556     7.41621721     5.20000000    25.90000000     2.47207240    156.2000000     55.0002778       42.731
DO              9      8.52222222     1.81092364     6.10000000    11.30000000     0.60364121     76.7000000      3.2794444       21.249
NITRATE         9      0.49722222     0.41609127     0.00500000     1.20000000     0.13869709      4.4750000      0.1731319       83.683
AMMONIA         9      0.24833333     0.40544728     0.00500000     1.10000000     0.13514909      2.2350000      0.1643875      163.267
TKJELDN         9      1.04444444     0.66729137     0.50000000     2.30000000     0.22243046      9.4000000      0.4452778       63.890
TOTP            9      0.11533333     0.09274292     0.04800000     0.29000000     0.03091431      1.0380000      0.0086013       80.413
DISSP           9      0.04188889     0.01804470     0.01300000     0.08000000     0.00601490      0.3770000      0.0003256       43.078
TSS             9     28.22222222    20.17286406    11.00000000    60.00000000     6.72428802    254.0000000    406.9444444       71.479
VSS             9      9.77777778     7.83865068     2.00000000    24.00000000     2.61288356     88.0000000     61.4444444       80.169
TURBID          9     38.72222222    46.05572108     8.70000000   140.00000000    15.35190703    348.5000000   2121.1294444      118.939
COD             9     20.77777778     8.52610371    15.00000000    40.00000000     2.84203457    187.0000000     72.6944444       41.035
LTURBID         9      1.36669979     0.43648223     0.93951925     2.14612804     0.14549408     12.3002961      0.1905167       31.937
SECCHI          8      0.41351010     0.17853043     0.15151515     0.65656566     0.06312004      3.3080808      0.0318731       43.174
LSECCHI         8     -0.42676602     0.21941447    -0.81954394    -0.18272184     0.07757473     -3.4141282      0.0481427      -51.413
NLSECCHI        8     -0.98266507     0.50522048    -1.88706965    -0.42073258     0.17862241     -7.8613206      0.2552477      -51.413
TSISD           8     74.17686029     7.28879086    66.06988807    87.22466024     2.57697672    593.4148823     53.1264722        9.826
TSICHLOR        7     49.93754634    11.84010993    34.34857102    63.99456329     4.47514091    349.5628244    140.1882031       23.710
TP              9    115.33333333    92.74292426    48.00000000   290.00000000    30.91430809   1038.0000000   8601.2500000       80.413
TSITP           9     69.33084442     9.74755459    60.00000000    85.94946589     3.24918486    623.9775998     95.0148205       14.059
PERIOD          9      1.66666667     0.70710678     1.00000000     3.00000000     0.23570226     15.0000000      0.5000000       42.426
CODEDATE        9     10.66666667     3.94301449     5.65625000    16.84375000     1.31433816     96.0000000     15.5473633       36.965
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                              S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                      17
                                                                                       20:03 WEDNESDAY, AUGUST 25, 1982
VARIABLE        N          MEAN       STANDARD        MINIMUM         MAXIMUM      STD ERROR           SUM        VARIANCE         C.V.
                                      DEVIATION         VALUE           VALUE        OF MEAN

RUNNO          86    5.11627907     2.58692916     1.00000000       9.0000000     0.27895575    440.000000          6.6922       50.563
DAY            86   14.04651163     9.47927396     3.00000000      30.0000000     1.02217640   1208.000000         89.8566       67.485
YEAR           86   81.23255814     0.42494065    81.00000000      82.0000000     0.04582253   6986.000000          0.1806        0.523
SITE           86    5.33720930     2.85166810     1.00000000      10.0000000     0.30750328    459.000000          8.1320       53.430
FECAL          50  305.40000000  1270.37280403     0.00000000    9000.0000000   179.65794487  15270.000000    1613847.0612      415.970
PHYTO           0             .              .              .               .              .             .               .            .
CHLGRAC        58   17.69362069    12.35821549     0.00000000      57.8500000     1.62271319   1026.230000        152.7255       69.846
CHLORAU        58   21.67500000    13.47905526     0.00000000      61.5800000     1.76988666   1257.150000        181.6849       62.197
CHLORBU        58    2.29603448     2.11246338     0.00000000      11.1000000     0.27738003    133.170000          4.4625       92.005
CHLORCU        58    2.53310345     2.43335247     0.00000000      12.2800000     0.31951483    146.920000          5.9212       96.062
PHEOPHY        58    6.55258621     4.99179276     0.00000000      24.1000000     0.65545450    380.050000         24.9180       76.190
SECCHI2X       76   23.39473684    14.15351918     2.00000000      52.0000000     1.62352000   1778.000000        200.3221       60.499
DEPTH          86   12.91860465     7.36280815     2.00000000      28.0000000     0.79395202   1111.000000         54.2109       56.994
PH             83    7.50240964     0.64011735     6.20000000       8.8000000     0.07026201    622.700000          0.4098        8.532
COND           84  225.19047619    42.55017625   120.00000000     419.0000000     4.64260484  18916.000000       1810.5175       18.895
TALK           84   58.98809524    14.17999103    30.00000000      90.0000000     1.54716386   4955.000000        201.0721       24.039
H2OTEMP        80   18.13250000     7.46873271     2.40000000      28.5000000     0.83502970   1450.600000         55.7820       41.190
DO             80    8.44250000     2.80888171     0.00000000      13.8000000     0.31404252    675.400000          7.8898       33.271
NITRATE        84    0.53642857     0.55187827     0.00500000       2.7000000     0.06021486     45.060000          0.3046      102.880
AMMONIA        85    0.31700000     0.43581082     0.00500000       2.2000000     0.04727032     26.945000          0.1899      137.480
TKJELDN        85    1.48823529     0.91240287     0.50000000       4.6000000     0.09896399    126.500000          0.8325       61.308
TOTP           85    0.19769412     0.18747076     0.03000000       0.8200000     0.02033406     16.804000          0.0351       94.829
DISSP          85    0.07015294     0.09425580     0.00400000       0.5960000     0.01022348      5.963000          0.0089      134.358
TSS            85   66.28235294    92.38256532    10.00000000     630.0000000    10.02029609   5634.000000       8534.5384      139.377
VSS            85   16.49411765    15.08359526     0.00000000      95.0000000     1.63604561   1402.000000        227.5148       91.448
TURBID         85   69.64470588   106.00152122     6.40000000     600.0000000    11.49747926   5919.800000      11236.3225      152.203
COD            81   28.00000000    16.69281282    13.00000000     110.0000000     1.85475698   2268.000000        278.6500       59.617
LTURBID        85    1.50349486     0.50931363     0.30617997       2.7781513     0.05524282    127.797063          0.2594       33.875
SECCHI         76    0.29538809     0.17870605     0.02525253       0.6565657     0.02049899     22.449495          0.0319       60.499
LSECCHI        76   -0.66659452     0.41777635    -1.59769519      -0.1827218     0.04792223    -50.661184          0.1745      -62.673
NLSECCHI       76   -1.53489061     0.96196559    -3.67882912      -0.4207326     0.11034502   -116.651686          0.9254      -62.673
TSISD          76   82.14379067    13.87822987    66.06988807     113.0742853     1.59194215   6242.928091        192.6053       16.895
TSICHLOR       57   56.10862589     8.38686130    34.21418089      70.3778875     1.11086692   3198.191675         70.3394       14.949
TP             85  197.69411765   187.47376112    30.00000000     820.0000000    20.33403902  16804.000000      35145.2863       94.829
TSITP          85   74.84975397    12.51664324    53.21928095     100.9451760     1.35762057   6362.229088        156.6664       16.722
PERIOD         86    1.67441860     0.67635460     1.00000000       3.0000000     0.07293319    144.000000          0.4575       40.393
CODEDATE       86   10.82267442     3.74138238     5.65625000      16.8437500     0.40344364    930.750000         13.9979       34.570
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                          S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                 20:03 WEDNESDAY, AUGUST 25, 1982

                       L                         S
                       O          C  C  C  C  P  E                       H          N     A    T
                       C          H  H  H  H  H  C                       2          I     M    K
    R   M              A    F  P  L  L  L  L  E  C   D                   O          T     M    J           D
    U   O       Y   S  T    E  H  O  O  O  O  O  H   E         C   T     T          R     O    E     T     I
 O  N   N   D   E   I  I    C  Y  R  R  R  R  P  I   P         O   A     E          A     N    L     O     S
 B  N   T   A   A   T  O    A  T  A  A  B  C  H  2   T    P    N   L     M    D     T     I    D     T     S
 S  O   H   Y   R   E  N    L  O  C  U  U  U  Y  X   H    H    D   K     P    O     E     A    N     P     P

77  9  04  27  82   1  T   10  .  .  .  .  .  .  .  21    .    .   .  15.0  9.0  1.20  0.80  2.1  0.29  0.05
78  9  04  27  82   2  T   10  .  .  .  .  .  .  2  13  6.7  252  40  15.6  7.3  1.30  0.81  2.5  0.38  0.04
79  9  04  27  82   3  T  200  .  .  .  .  .  .  6   3  6.8  394  90  16.4  6.3  0.59  2.20  4.2  0.36  0.05
80  9  04  77  82   4  T    0  .  .  .  .  .  .  6  16  6.6  215  45  14.9  7.7  1.30  0.77  2.1  0.33  0.05
81  9  04  27  82   5  T   30  .  .  .  .  .  .  6  15  6.7  220  35  15.5  7.8  1.30  0.70  2.2  0.34  0.07
82  9  04  27  82   6  T   40  .  .  .  .  .  .  6  12  6.6  213  45  16.0  7.6  1.30  0.70  2.2  0.35  0.02
83  9  04  27  82   7  T    .  .  .  .  .  .  .  6   6  6.7  214  50  17.8  7.9     .  0.66  1.9  0.34  0.02
84  9  04  27  82   8  T   20  .  .  .  .  .  .  4   9  6.6  214  45  15.6  7.1  1.30  0.71  2.4  0.35  0.02
85  9  04  27  82   9  T   40  .  .  .  .  .  .  6   5  6.6  419  70  16.9  6.7  1.30  0.84  2.3  0.29  0.01
86  9  04  27  82  10  B    .  .  .  .  .  .  .  .  21    .    .   .  14.9  8.8  1.20  0.77  1.9  0.28  0.06

                                                                      N                       T                               C
                                   L                      L           L                       S                               O
                     T             T          S           S           S                       I                        P      D
                     U             U          E           E           E           T           C              T         E      E
                     R             R          C           C           C           S           H              S         R      D
 O       T    V      B     C       B          C           C           C           I           L              I         I      A
 B       S    S      I     O       I          H           H           H           S           O      T       T         O      T
 S       S    S      D     D       D          I           I           I           D           R      P       P         D      E

77      60   20    140    30    2.14613     .             .          .            .           .    290    85.9495      1   16.8435
78     140   46    200    42    2.30103    0.0252525    -1.5977    -3.6788     113.074        .    380    89.8489      1   16.8438
79     170   34     90    50    1.95424    0.0757576    -1.1206    -2.5802      97.225        .    360    89.0689      1   16.8439
80      80   46    170    34    2.23045    0.0757576    -1.1206    -2.5802      97.225        .    330    87.8136      1   16.8439
81      80    6    170    38    2.23045    0.0757576    -1.1206    -2.5802      97.225        .    340    88.2443      1   16.8438
82     100   38    170    39    2.23045    0.0757576    -1.1206    -2.5802      97.225        .    350    88.6625      1   16.8439
83      75   26    170    35    2.23045    0.0757576    -1.1206    -2.5802      97.225        .    340    88.2443      1   16.8439
84     100   12    180    37    2.25527    0.0505051    -1.2967    -2.9857     103.074        .    350    88.6625      1   16.8439
85      80   32    130    37    2.11394    0.0757576    -1.1206    -2.5802      97.225        .    290    85.9495      1   16.8439
86      36   13    140    30    2.14613     .             .          .            .           .    280    85.4432      1   16.8439
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                                        STATISTICAL ANALYSIS SYSTEM
                                                                          20:03 WEDNESDAY, AUGUST 25, 1982

OBS RUNNO MONTH DAY YEAR SITE LOCATION FECAL PHYTO CHLORAC CHLORAU CHLORBU CHLORCU PHEOPHY SECCHI2X DEPTH  PH  COND  T4  H2OTEMP  DO  NITRATE AMMONIA TKJELDN

58    7    12   10   81    2     T        0    .    22.90   27.71   0.37    4.49    7.46     48    12.0  8.3  201   65   4.8   11.8   0.40    0.19    1.0
59    7    12   10   81    3     T       10    .    24.91   28.04   0.30    5.93    4.59     30     2.0  8.1  310   55   2.4   12.5   0.31    0.05    1.0
60    7    12   10   81    4     T        2    .     7.74    8.42   0.00    0.43    0.90     26    20.5  7.8  197   60   5.3   10.9   0.73    0.05    0.8
61    7    12   10   81    5     T       10    .    14.61   17.63   0.47    3.22    4.72     48    14.0  8.1  199   60   5.0   10.8   0.62    0.34    0.7
62    7    12   10   81    6     T       30    .    14.51   17.04   0.66    1.79    3.93     52    12.0  8.1  199   65   4.7   11.3   0.52    0.12    0.7
63    7    12   10   81    7     T       12    .    14.49   17.15   1.09    4.87    4.25     52     6.0  8.2  200   55   5.1   12.2   0.58    0.31    0.7
64    7    12   10   81    8     T        8    .    13.95   15.89   0.75    3.26    2.99     52     9.0  8.1  200   65   4.8   11.6   0.51    0.05    0.5
65    7    12   10   81    9     T        0    .    42.16   49.02   2.83   12.28   10.83     28     4.0  8.8  256   70   3.8   13.0   0.05    0.05    1.2
66    7    12   10   81   10     B        .    .      .       .       .       .       .        .    21.0  7.8  197   55   5.1   12.8   0.79    0.05    0.5
67    8    04    8   82    1     T       70    .      .       .       .       .       .       12    22.0  6.7  193   40   8.3    9.3   0.91    1.10    2.3
68    8    04    8   82    2     T      200    .      .       .       .       .       .        2    11.5  6.2  154   40   7.0    7.7   1.10    0.78    4.3
69    8    04    8   82    3     T      490    .      .       .       .       .       .        4     4.0  6.7  309   50   4.4    9.1   1.40    0.55    2.8
70    8    04    8   82    4     T      100    .      .       .       .       .       .        2    19.5   .   185   40    .      .    1.00    1.90    3.1
71    8    04    8   82    5     T       20    .      .       .       .       .       .        2    13.5  7.3  180   40    .      .    1.10    0.89    2.9
72    8    04    8   82    6     T      230    .      .       .       .       .       .        2    11.5  7.1  180   40    .      .    1.00    1.00    2.9
73    8    04    8   82    7     T      220    .      .       .       .       .       .        2     6.0  7.1  185   40    .      .    1.10    0.90    2.9
74    8    04    8   82    8     T      200    .      .       .       .       .       .        2     9.0  7.1  195   40    .      .    1.10    0.82    3.1
75    8    04    8   82    9     T      500    .      .       .       .       .       .        2     5.0  7.0  245   40    .      .    1.60    0.50    4.6
76    8    04    8   82   10     B        .    .      .       .       .       .       .        .    22.0  6.7  200   40   8.3    9.3   0.93    1.10    2.3

OBS  TOTP  DISSP  TSS  VSS  TURBIC  COD  LTURBID   SECCHI    LSECCHI  NLSECCHI   TSISD   TSICHLOR   TP    TSITP  PERIOD  CODEDATE

58   0.04  0.02    13    2     6.9   23  0.83885  0.606061  -0.2175  -0.5008    67.225  61.2865    40   57.370    3    12.3125
59   0.06  0.03    27    1    10.0   28  1.00000  0.378788  -0.4216  -0.9709    74.005  62.1119    60   63.219    3    12.3125
60   0.09  0.04    10    1    13.0   20  1.11394  0.328283  -0.4838  -1.1134    76.070  50.6449    90   69.069    3    12.3125
61   0.04  0.02    17    3     7.7   16  0.88649  0.606061  -0.2175  -0.5008    67.225  56.8774    40   57.370    3    12.3125
62   0.03  0.02    14    3     7.8   17  0.89209  0.656566  -0.1827  -0.4207    66.070  56.8101    30   53.219    3    12.3125
63   0.03  0.02    12    0     7.5   16  0.87506  0.656566  -0.1827  -0.4207    66.070  56.7965    30   53.219    3    12.3125
64   0.04  0.03    20    5     7.7   18  0.88649  0.656566  -0.1827  -0.4207    66.070  56.4239    40   57.370    3    12.3125
65   0.09  0.03    35   15     8.2   28  0.91381  0.353535  -0.4516  -1.0398    75.001  67.2741    90   69.069    3    12.3125
66   0.05  0.03    17    0    15.0   15  1.17609   .          .        .          .         .        50   60.589    3    12.3125
67   0.26  0.08    60   15    91.0   40  1.95904  0.151515  -0.8195  -1.8871    87.225     .       260   84.374    1    16.2500
68   0.82  0.24   430   65   530.0  110  2.72428  0.025253  -1.5977  -3.6788   113.074     .       820  100.945    1    16.2500
69   0.51  0.25   230   38   265.0   59  2.42325  0.050505  -1.2967  -2.9857   103.074     .       510   94.094    1    16.2500
70   0.35  0.21   110   20   165.0    .  2.21748  0.025253  -1.5977  -3.6788   113.074     .       350   88.562    1    16.2500
71   0.42  0.21   190   32   235.0    .  2.37107  0.025253  -1.5977  -3.6788   113.074     .       420   91.393    1    16.2500
72   0.43  0.22   160   26   225.0   50  2.35218  0.025253  -1.5977  -3.6788   113.074     .       430   91.632    1    16.2500
73   0.40  0.21   150   30   210.0    .  2.32222  0.025253  -1.5977  -3.6788   113.074     .       400   90.569    1    16.2500
74   0.40  0.21   140   30   225.0   47  2.35218  0.025253  -1.5977  -3.6788   113.074     .       400   90.569    1    16.2500
75   0.79  0.17   630   35   600.0  110  2.77815  0.025253  -1.5977  -3.6788   113.074     .       790  100.407    1    16.2500
76   0.28  0.11    60   17    96.0    .  1.98227   .          .        .          .         .       280   85.443    1    16.2500
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                                   S T A T I S T I C A L   A N A L Y S I S   S Y S T E M
                                                                              20:07 WEDNESDAY, AUGUST 25, 1982  3

OBS RUNNO MONTH DAY YEAR SITE LOCATION FECAL PHYTO CHLORAC CHLORAU CHLORBU CHLORCU PHEOPHY SECCHI2X DEPTH  PH  COND TALK H2OTEMP   DO  NITRATE AMMONIA TKJELDN

 39   5    10    6   81    3     T        0    .     31.67   37.31    3.02    3.78    9.05     16      2.0  7.8  215   60   19.7     8.7  0.005    0.03    1.6
 40   5    10    6   81    4     T        0    .      4.42    5.51    0.45    0.46    1.77     16     15.0  7.1  224   60   19.4     6.7  0.530    0.04    0.8
 41   5    10    6   81    5     T        0    .      7.40    9.24    0.52    1.07    2.96     20     15.0  7.2  218   60   19.1     7.1  0.360    0.19    1.0
 42   5    10    6   81    6     T      500    .     16.83   20.01    2.78    1.51    5.33     18     11.5  7.3  218   70   20.2     8.0  0.270    0.13    1.1
 43   5    10    6   81    7     T      800    .     10.29   13.10    1.18    2.17    4.61     20      0.0  7.1  223   55   20.4     6.5  0.290    0.13    1.1
 44   5    10    6   81    8     T      800    .     13.69   16.92    2.14    1.45    5.37     22      9.0  7.2  210   60   19.5     7.4  0.260    0.17    1.2
 45   5    10    6   81    9     T      100    .     17.93   46.59    4.33    3.10   14.14     14      4.5  7.2  215   55   18.9     8.2  0.100    0.08    1.6
 46   5    10    6   81   10     B        .    .       .       .       .       .       .        .     21.0  7.0  275   70   18.3     6.8  0.570    0.02    0.8
 47   6    11    5   81    1     T        .    .      1.47    1.63    0.20    0.57    0.26     26     26.0  7.2  211   55   13.9     8.2  0.730    0.04    0.6
 48   6    11    5   81    2     T        .    .      6.97    9.14    0.35    0.78    3.49     32     12.0  7.4  209   55   14.7     8.5  0.530    0.04    0.7
 49   6    11    5   81    3     T        .    .     20.09   25.17    1.49    2.83    8.17     18      2.0  7.0  254   60   15.9     7.0  0.290    0.13    1.3
 50   6    11    5   81    4     T        .    .      5.13    5.58    0.06    1.08    0.60     26     15.0  7.3  203   55   14.8     5.6  0.700    0.02    0.6
 51   6    11    5   81    5     T        .    .      5.83    7.49    0.29    1.24    2.56     26     15.0  7.2  209   60   14.8     7.7  0.630    0.04    0.6
 52   6    11    5   81    6     T        .    .     17.44   18.96    1.66    2.60    2.34     30     11.5  7.5  208   60   16.0     7.9  0.550    0.07    0.7
 53   6    11    5   81    7     T        .    .      3.73    4.93    0.15    0.09    1.10     28      6.0  7.1  216   60   15.5     6.5  0.560    0.09    1.0
 54   6    11    5   81    8     T        .    .      9.99   14.35    1.95    1.57    7.22     30      9.0  7.5  210   60   15.8     5.8  0.550    0.02    0.7
 55   6    11    5   81    9     T        .    .     27.99   35.21    4.45    1.30   12.04     16      4.5  6.9  247   65   15.7     7.7  0.340    0.36    1.6
 56   6    11    5   81   10     B        .    .       .       .       .       .       .        .     25.0  6.9  213   60   12.7     5.5  0.720    0.08    0.6
 57   7    12   10   81    1     T       20    .      3.42    4.20    0.00    0.00    1.17     28     21.0  7.6  197   50    5.2    10.9  0.620    0.05    0.5


OBS  TOTP   DISSP  TSS  VSS  TURBID  COD  LTURBID   SECCHI   LSECCHI  NLSECCHI   TSISD  TSICHLOR   TP    TSITP  PERIOD  CODEDATE

 39  0.194  0.042   95   15   38.0    30  1.57978  0.176768  -0.7526  -1.7329   85.001  64.4673   194   80.150    2    10.1875
 40  0.094  0.034   27   10   33.0    14  1.51851  0.202020  -0.6946  -1.5994   83.074  45.1485    94   69.696    2    10.1875
 41  0.079  0.032   30    5   27.0    15  1.43136  0.252525  -0.5977  -1.3762   79.855  50.2042    79   67.188    2    10.1875
 42  0.072  0.023   25    5   20.0    17  1.30103  0.227273  -0.6435  -1.4816   81.375  58.2652    72   65.650    2    10.1875
 43  0.090  0.024   40    5   25.0    19  1.39794  0.252525  -0.5977  -1.3762   79.855  53.4386    90   69.069    2    10.1875
 44  0.079  0.024   35   10   23.0    17  1.36173  0.277778  -0.5563  -1.2809   78.480  56.2394    79   67.188    2    10.1875
 45  0.182  0.032   85   20   41.0    28  1.61278  0.176768  -0.7526  -1.7329   85.001  66.2368   182   79.228    2    10.1875
 46  0.099  0.042   35    5   41.0    16  1.61278      .         .        .         .        .        99   70.464    2    10.1875
 47  0.079  0.035   37   26   23.0    18  1.36173  0.328283  -0.4838  -1.1139   76.070  34.3486    79   67.188    2    10.1875
 48  0.058  0.024   31   15   14.0    18  1.14613  0.404040  -0.3936  -0.9062   73.074  49.6169    58   62.730    2    11.1563
 49  0.163  0.029   55   33   25.0    34  1.39794  0.227273  -0.6435  -1.4816   81.375  60.0022   163   77.638    2    11.1563
 50  0.065  0.037   28   16   19.0    18  1.27875  0.328283  -0.4838  -1.1139   76.070  46.6099    65   64.374    2    11.1563
 51  0.055  0.028   31   17   18.0    19  1.25527  0.328283  -0.4838  -1.1139   76.070  47.9486    65   64.374    2    11.1563
 52  0.053  0.028   40   15   14.0    20  1.14613  0.378788  -0.4216  -0.9708   74.005  58.4145    63   63.923    2    11.1563
 53  0.063  0.033   26   16   15.0    20  1.17609  0.353535  -0.4516  -1.0398   75.001  43.4834    63   63.923    2    11.1563
 54  0.096  0.060   41   20   15.0    22  1.17609  0.378788  -0.4216  -0.9708   74.005  53.1483    96   70.000    2    11.1563
 55  0.169  0.062   60   22   29.0    33  1.46240  0.202020  -0.6946  -1.5994   83.074  63.2555   169   78.159    2    11.1563
 56  0.068  0.044   46   21   32.0    19  1.50515      .         .        .         .        .        88   58.745    2    11.1563
 57  0.050  0.040   20    2   15.0    15  1.17609  0.353535  -0.4516  -1.0398   75.001  42.6322    50   60.589    3    12.3125
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                                   STATISTICAL ANALYSIS SYSTEM
                                                                  20:03 WEDNESDAY, AUGUST 25, 1982  2

OBS RUNNO MONTH DAY YEAR SITE LOCATION FECAL PHYTO CHLORAC CHLORAU CHLORBU CHLORCU PHEOPHY SECCHI2X DEPTH  PH  COND TALK H2OTEMP   DO  NITRATE AMMONIA TKJELDN

 20   3    07   30   81    2     T        .    .     0.00    0.00    0.00    0.03    0.00     20     12.5  6.9  185  40   26.3     5.0  0.150   0.240    1.3
 21   3    07   30   81    3     T        0    .     2.75    3.98    0.55    0.00    2.06     14      2.5  6.4  120  35   26.3     2.6  0.320   0.440    2.1
 22   3    07   30   81    4     T       10    .    26.84   28.68    1.71    2.58    2.61     28     17.5  7.7  212  50   27.6     9.0  0.250   0.100    2.3
 23   3    07   30   81    5     T        0    .    24.20   27.04    1.73    2.60    4.35     28     14.0  7.8  204  60   27.0     9.6  0.090   0.170    1.6
 24   3    07   30   81    6     T       10    .    43.31   47.59    5.56    4.20    6.88     24     11.5  7.9  208  55   28.0     9.9  0.070   0.030    1.4
 25   3    07   30   81    7     T      200    .    57.85   61.58   11.10    2.88    6.52     24      6.5  7.9  202  45   27.3    10.4  0.050   0.020    1.8
 26   3    07   30   81    8     T        0    .    45.00   47.58    7.55    2.21    4.35     24      9.5  8.2  205  45   28.2    10.3  0.030   0.020    1.5
 27   3    07   30   81   10     M        .    .      .       .       .       .       .        .     28.0  6.7  316  75   20.2     0.0  0.005   1.000    2.1
 28   4    09    3   81    1     T        .    .    25.[illegible]   28.82    2.17    1.92    4.46     48     27.5  7.4  215  75   24.7     6.6  0.005   0.040    0.8
 29   4    09    3   81    2     T        .    .    32.66   35.64    2.14    1.00    4.39     36     12.0  7.9  200  60   25.0     6.6  0.005   0.020    1.0
 30   4    09    3   81    3     T        .    .    24.03   28.31    2.22    2.96    6.87     14      2.0  8.0  155  45   25.6     7.9  0.070   0.120    1.6
 31   4    09    3   81    4     T        .    .    19.42   21.51    2.31    0.18    3.34     38     18.0  8.3  210  65   25.5     6.2  0.005   0.040    0.9
 32   4    09    3   81    5     T        .    .    26.67   29.92    3.19    1.79    5.58     38     15.0  8.3  205  65   26.1     8.0  0.005   0.005    1.0
 33   4    09    3   81    6     T        .    .    15.43   16.92    1.58    1.56    2.31     28     12.0  8.3  215  65   26.0     7.7  0.005   0.040    1.0
 34   4    09    3   81    7     T        .    .    26.92   31.51    3.71    2.14    7.54     28      6.5  8.3  210  65   27.0     8.4  0.005   0.010    1.0
 35   4    09    3   81    8     T        .    .    20.11   21.93    1.17    0.95    2.67     26      9.5  8.3  215  65   26.1     8.0  0.005   0.005    0.9
 36   4    09    3   81   10     B        .    .      .       .       .       .       .        .     27.5  7.3  255  90   20.2     0.0  0.005   1.300    2.4
 37   5    10    6   81    1     T        0    .     2.50    4.09    0.28    0.00    2.62     18     21.0  7.1  225  70   18.3     7.0  0.580   0.035    0.8
 38   5    10    6   81    2     T        0    .    1[illegible].36   14.77    1.12    1.25    3.85     20     11.5  7.2  219  60   18.9     8.2  0.240   0.230    1.2

OBS  TOTP   DISSP  TSS VSS TURBID COD LTURBID  SECCHI   LSECCHI  NLSECCHI  TSISD  TSICHLOR  TP   TSITP  PERIOD CODEDATE

 20  0.171  0.084   25   6  25.0   23  1.39794  0.252525  -0.5977  -1.3762  79.855     .      171  78.329    2     7.9375
 21  0.642  0.320   90  17  71.0   35  1.85126  0.176768  -0.7526  -1.7329  85.001  40.4932   642  97.415    2     7.9375
 22  0.278  0.055   47  23  21.0   43  1.32222  0.353535  -0.4516  -1.0398  75.001  62.8439   278  85.340    2     7.9375
 23  0.191  0.066   41  16  20.0  [illegible]  1.30103  0.353535  -0.4516  -1.0398  75.001  61.8282   191  79.925    2     7.9375
 24  0.165  0.048   70  17  22.0  [illegible]  1.34242  0.303030  -0.5185  -1.1939  77.225  67.5381   165  77.814    2     7.9375
 25  0.237  0.045   41  16  22.0  [illegible]  1.34242  0.303030  -0.5185  -1.1939  77.225  70.3779   207  81.085    2     7.9375
 26  0.191  0.041   38  15  26.0   29  1.41497  0.303030  -0.5185  -1.1939  77.225  67.9136   191  79.925    2     7.9375
 27  0.523  0.596   80  18  32.0   22  1.50515      .         .        .        .        .      623  96.981    2     7.9375
 28  0.048  0.013   12   5   9.8   17  0.99123  0.606061  -0.2175  -0.5008  67.225  62.5056    48  60.000    2     9.0938
 29  0.095  0.028   17   9  14.0   22  1.14613  0.454545  -0.3424  -0.7885  71.375  64.7693    95  69.849    2     9.0938
 30  0.254  0.067   70  15  45.0   32  1.65321  0.176768  -0.7526  -1.7329  85.001  61.7590   254  84.037    2     9.0938
 31  0.071  0.009   16   8   8.1   20  0.90849  0.479798  -0.3189  -0.7344  70.595  59.6694    71  65.648    2     9.0938
 32  0.0[illegible]  0.010   15   8  10.0   22  1.00000  0.479798  -0.3189  -0.7344  70.595  62.7816    89  68.908    2     9.0938
 33  0.074  0.004   26  1[illegible]   6.4   22  0.80618  0.353535  -0.4516  -1.0398  75.001  57.4132    74  66.245    2     9.0938
 34  0.071  0.009   16   9  14.0   22  1.14613  0.353535  -0.4516  -1.0398  75.001  62.8731    71  65.648    2     9.0938
 35  0.062  0.009   22  10  14.0   22  1.14613  0.328283  -0.4838  -1.1139  76.070  60.011[illegible]    62  63.692    2     9.0938
 36  0.508  0.254   27   9  16.0   25  1.20412      .         .        .        .        .      508  94.037    2     9.0938
 37  0.093  0.046   30   5  37.0   16  1.56820  0.227273  -0.6435  -1.4816  81.375  39.5581    93  69.542    2    10.1875
 38  0.079  0.[illegible]0   30   5  22.0   18  1.34242  0.252525  -0.5977  -1.3762  79.855  55.2367    79  67.188    2    10.1875
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                                        S T A T I S T I C A L   A N A L Y S I S   S Y S T E M                                         1
                                                                                                     20:03 WEDNESDAY, AUGUST 25, 1982

OBS RUNNO MONTH DAY YEAR SITE LOCATION FECAL FMTTO CHLORAC CHLORAU CHLORBU CHLORCU PHEOPHY SECCHI2X DEPTH  PH  COND TALK H2OTEMP   DO  NITRATE AMMONIA TKJELDN

  1   1    05   21   81    1     T       58    .     5.80    9.55    1.57    1.48    6.38     38    21.0  7.9  248   85   19.9   11.3   0.210   0.080   0.7
  2   1    05   21   81    2     T        2    .    12.20   26.38    4.23    3.61   24.10     30    11.5  8.3  264   75   19.4   13.7   0.080   0.030   1.0
  3   1    05   21   81    3     T     9000    .     1.45    2.99    0.43    0.23    2.61      6     2.5  6.5  214   45   19.5    7.6   2.700   0.450   2.5
  4   1    05   21   81    4     T       28    .     8.21   14.35    4.69   12.07   10.95     32    20.0  8.2  247   70   20.4   12.6   0.160   0.010   0.9
  5   1    05   21   81    5     T      380    .     3.77   10.59    2.44    5.53    8.37     36    13.0  7.8  248   90   19.2   11.9   0.210   0.060   0.7
  6   1    05   21   81    6     T      260    .     5.47   11.62    3.58    7.05   10.81     30    11.0  8.2  246   90   20.4   13.3   0.160   0.020   1.0
  7   1    05   21   81    7     T      300    .    10.89   19.50    4.21    4.57   14.84     26     9.0  8.3  247   90   20.9   13.5   0.160   0.020   1.0
  8   1    05   21   81    8     T      350    .    10.16   21.17    3.68    2.32   18.77     24     3.0  8.4  247   75   23.1   13.8   0.190   0.070   1.1
  9   1    05   21   81   10     B        .    .      .       .       .       .       .        .    21.0  7.2  245   70   14.5    8.2     .       .      .
 10   2    06   18   81    1     T        .    .    30.18   35.35    5.92    4.11    8.78     40    28.0  7.4  220   80   25.0    9.3   0.210   0.080   0.7
 11   2    06   18   81    2     T        .    .      .       .       .       .       .       32    11.5  7.6  245   70   26.5    7.2   2.700   0.450   2.5
 12   2    06   18   81    3     T        .    .    2 .64   30.99    4.29    3.16   12.37     16     2.0  7.9  260   70   27.5    8.3   0.160   0.010   0.9
 13   2    06   18   81    4     T        .    .    17.53   22.06    2.31    2.64    7.48     46    19.5  8.7  250   65   28.0   10.4   0.210   0.060   0.7
 14   2    06   18   81    5     T        .    .    22.00   27.40    2.37    1.88    8.80     36    13.5  8.5  250   65   27.5    9.3   0.160   0.020   1.0
 15   2    06   18   81    6     T        .    .    25.46   33.62    3.58    4.12   13.55     28    11.5  8.1  255   65   28.5   10.0   0.160   0.020   1.0
 16   2    06   18   81    7     T        .    .    20.88   27.20    2.73    0.71   10.44     28     6.0  8.3  255   65   28.0    8.8   0.190   0.070   1.1
 17   2    06   18   81    8     T        .    .    23.39   28.98    3.96    1.95    9.35     30     9.0  8.7  250   70   28.0   10.0   0.270   0.110   0.7
 18   2    06   18   81   10     B        .    .      .       .       .       .       .        .    28.0  7.4  275   70   16.0    0.3   0.080   0.030   1.0
 19   3    07   30   81    1     T        0    .    17.61   29.29    2.20    1.40   19.39     52    28.0  7.1  225   30   25.9    6.1   0.010   0.040   0.9

OBS  TOTP   DISSP   TSS  VSS  TURBID  COD  LTURBID   SECCHI    LSECCHI  NLSECCHI   TSISD   TSICHLOR   TP    TSITP   PERIOD  CODEDATE

  1  0.058  0.033    11    6    12.0   16   1.07918  0.479798  -0.3189   -0.7344  70.5950   47.8142    58  62.7302    1     5.6563
  2  0.084  0.023    17   12    14.0   25   1.14613  0.378788  -0.4216   -0.9708  74.0054   55.1089    84  68.0735    1     5.6563
  3  0.664  0.274   270   44   240.0   53   2.38021  0.075758  -1.1206   -2.5802  97.2247   34.2142   664  97.9008    1     5.6563
  4  0.058  0.023    19   11    12.0   20   1.07918  0.404040  -0.3936   -0.9062  73.0743   51.2232    58  62.7302    1     5.6563
  5  0.054  0.023    18    7    12.0   18   1.07918  0.454545  -0.3424   -0.7885  71.3750   47.7633    54  61.6993    1     5.6563
  6  0.086  0.030    25    7    16.0   22   1.25527  0.378788  -0.4216   -0.9708  74.0054   47.2395    86  68.4130    1     5.6563
  7  0.106  0.027    30   12    20.0   23   1.30103  0.328283  -0.4838   -1.1139  76.0699   53.9946   106  71.4296    1     5.6563
  8  0.113  0.030    35   12    25.0   24   1.39794  0.303030  -0.5185   -1.1939  77.2247   53.3139   113  72.3522    1     5.6563
  9    .      .       .    .      .     .      .         .          .         .         .         .        .     .        1     5.6563
 10  0.058  0.033    11    6    12.0   16   1.07918  0.505051  -0.2967   -0.6831  69.8550   63.9946    58  62.7302    1     6.5625
 11  0.664  0.274   270   44   240.0   53   2.38021  0.404040  -0.3936   -0.9062  73.0743     .       664  97.9008    1     6.5625
 12  0.058  0.023    19   11    12.0   20   1.07918  0.202020  -0.6946   -1.5994  83.0743   61.5985    58  62.7302    1     6.5625
 13  0.054  0.023    18    7    12.0   18   1.07918  0.580808  -0.2360   -0.5433  67.8387   58.6649    54  61.6993    1     6.5625
 14  0.086  0.030    25    7    18.0   22   1.25527  0.454545  -0.3424   -0.7885  71.3750   60.8932    86  68.4130    1     6.5625
 15  0.106  0.027    30   12    20.0   23   1.30103  0.353535  -0.4516   -1.0398  75.0007   62.3261   106  71.4296    1     6.5625
 16  0.113  0.030    35   12    25.0   24   1.39794  0.353535  -0.4516   -1.0398  75.0007   60.3806   113  72.3522    1     6.5625
 17  0.056  0.037    22    6    17.0   13   1.23045  0.378788  -0.4216   -0.9708  74.0054   61.4942    56  62.2239    1     6.5625
 18  0.084  0.020    17   12    14.0   25   1.14613      .          .         .         .         .       84  68.0735    1     6.5625
 19  0.102  0.047    13    5     8.7   19   0.93952  0.656566  -0.1827   -0.4207  66.0699   58.7096   102  70.8746    2     7.9375
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WO  [illegible]                                          TEMP     -  TEMPERATURE          DEG. CELSIUS
WO      STAGE    =>       9
WO
WO
WO IDYRMODY TIME TIME TSSD TVSD NH3  TKN   N23  TPHS DSPH TURB COD  TEMP PH   DOXY COND STAGE
WO
WO F1820130 0930       310   46                             160
WO F1820130 1305       490   84                             190
WO F1820216 1240        65   26                              52
WO F1820218 1425        70   26                              14                       0.50
WO F1820314 1625       180   47       2.8        0.78       155  65
WO F182052A 2320 0030  410   95       4.4        0.92       540  80
WO F2820122 1700        88   32                              36
WO F2820216 1255       145   34                              72                       0.75
WO F3820219 1440        37   21                              18
WO F4820122 1743        37   26                              21                       0.30
WO F4820130 1000       190   48                             140
WO F4820216 1135        15    4                               5                       1.00
WO F4820216 1650        16    6                             5.8                       0.83
WO F4820217 1005        24   19                             7.2                       1.00
WO F4320218 1330        15    8                              13                       0.92
WO F4820313 1240        40   23       2.7        0.31       120  70
WO F4820314 1530        19   10       1.5        0.11      19.5  39
WO F4820325 1930 0330  230   42       3.6        0.76       150
WO F4820529 0135 0200  470  130       7.7         1.3       360
WO F4820607 2100 2115  610   20                              24
WO F4820607 2230 2245  300  140                              20
WO F4820608 0030 0045  240   80                             290
WO F5820122 1538        37   24                              17
WO F5820130 0900       225   55                             130                       2.25
WO F5820130 1335       265   45                             180
WO F5820217 1030        22   18                              16
WO F5820218 1512        15    6                             6.6                       4.00
WO F5820313 1155        70   36       3.5        0.54       125 715
WO F5820314 1503        41   16       2.1        0.27        46  65
WO F5920315 0945        48   20       3.4        0.44       115  71
WO F5820528 2300 2345 3000  220        21         1.9      3200 525
WO F5820529 0300 0045  200 6330        21         2.1      2600 480
WO F5820529 0100 0145 2100  870        22         3.1      2600
WO F5820529 0200 0245 1800  170        20         2.9      2200 400
WO F5820529 0300 0345  410   30        18         2.4      1850 320
WO F5820529 0400 0445 2900  270        15         2.5      1650 295
WO F5820529 0500 0545 1600  160        15         2.3      1550 270
WO F5820529 0745 1000  630   70        10         1.7      1200 210
WO F5820529 1130 1300 1400  180       7.5         1.6       900 155
WO F5820608 0900 0915  920   85                             240
WO F5820608 0930 0945  330   32                             185
WO F5820608 1000 1015  250   28                             170
WO F5820608 1030 1045  240   28                             160
WO F5820608 1100 1115  170   22                             125
WO F5820608 1130 1145  160   22                             110
WO F5820608 1200 1215  110   14                              80
WO F6820122 1715        64   25                              38                       0.37
WO F6820129 1815       655  100                             210
WO F6820130 0945       230   55                             145
WO F6820130 1257       190   48                             190
WO F6820216 1205        11    2                             6.6                       1.00
WO F6820216 1725        55   21                              14                       2.33
WO F6820217 0930        26   16                             8.7
WO F6820218 1405        21    4                              15                       3.00
WO F6820314 1610       280   44       4.2        0.83       230 130
WO F6820315 1113        78   30       4.1        0.48       160  79
WO F6820528 2336 2421 1300   75       3.7        0.96       300
WO F6820529 0036 0120  360   29       1.3        0.82        80  43
WO F6820529 0136 0221  200   21       1.6        0.91        27  47
WO F6820529 0236 0321   75    9       1.6        0.99        14  53
WO F6820529 0336 0421 1300  120       7.2         1.5       190 195
WO F6820529 0436 0551  180   11       3.1        0.84        54
WO F6820529 0936 1021  150   20       3.6        0.74       130
WO F6820618 0915       560   80                             160
WO F7820122 1638        70   29                              22                       1.00
WO F7820130 0840       250   33                             230
WO F7820130 1200       170   42                             220
WO F7820130 1430       765   76                             215
WO F7820216 1500        60   23                              29                       0.92
WO F7820217 1116        38   20                              19                       0.83
WO F7820218 1628       100   28                              38                       0.92
WO F7820225 1900 2200  120   14       1.2        0.12        34                       0.08
WO F7820314 1655       780   55       4.8        0.54       260 113
WO F7820315 1237       120   32       1.6        0.18        61  30
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WO F7820326 0400 0700   60   11       0.6        0.07        13  22                   0.05
WO F7820528 2300 234519100 1000
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WO F7820529 0400 051519100 1000
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WO F3820130 1030       220   75                              80
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118

120<

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WQ FA820218 1245         36   30                                  30
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WQ FA820416 1830 1850   230   65          12           4.8         160
WQ FA820416 1900 1930   195   85          19           7.7         120
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WQ G1820122 1600        128   39                                  17                               9.12
WQ G1820125 1305         25   22   1.5   3.9   2.0  0.92          26    60   0.0  8.3  11.5  227   4.55
WQ G1820129 1645         18    4                                  11         0.0  7.4  10.4  467   4.15
WQ G1820130 1210        440   85                                 175                              13.40
WQ G1820216 1410         31   19                                  25                               5.63
WQ G1820216 1825         70   35                                  24                               6.99
WQ G1820217 1100         41   25                                  19                               8.40
WQ G1820218 1738         35   23                                  16                               8.77
WQ G1820303 1100         27    8                                  17         3.9  7.4  11.3  343   5.28
WQ G1820305 0950         43   17                                  25         0.5  7.5  11.8  370   5.24
WQ G1820308 1410         33   17   3.4   6.2   2.0  0.73  0.43    15    97   2.5  8.0  10.1  484   4.90
WQ G1820310 1050         11   10                                 6.9         3.3  7.3        463   4.84
WQ G1820312 1630                                                  54        11.4  6.8  10.0  404
WQ G1820313 1358        320   43         5.3        0.90         210   113                         6.13
WQ G1820314 1445         85   30         3.6        0.68         130    71                         5.23
WQ G1820315 1805        130   25         2.5        0.70          15    81                         6.00
WQ G1820319 1040 1640   690  100         4.0         1.2                                           7.88
WQ G1820320 0240 0840   250   80         2.6        0.77          48    69
WQ G1820320 1240 1840   125   35         2.2        6.67          82                               5.55
WQ G1820321 1105         65   14                                  53         8.6  7.0   8.7  382   5.03
WQ G1820325 0430 1330   130   26         2.3        0.58         110    60
WQ G1820325 0930 1330   650   90         4.6         1.1         240
WQ G1820327 0910         65   36                                  74         4.4  7.1  11.3  251   5.11
WQ G1820329 1730         31   13   1.2   1.9   .81  0.28  0.15    44    27        6.3        131   6.37
WQ G1820329 1825         48   21  0.34   2.8   2.1  0.37  0.17    40    42  10.6  7.0  10.3  354   4.91
WQ G1820331 1453         65   21                                  38        14.5  7.8  10.8  423   4.86
WQ G1820402 1035         36   18                                  22        13.3  6.5   8.5  540   4.79
WQ G1820404 2106 0206  1700  210         8.5         1.5        1200   235
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WQ G1820405 0906 0406   510  110         5.4         1.1         620
WQ G1820405 1506 2006   440  110         4.6        0.93         530   120
WQ G1820405 1720        330   44                                 290         6.8  7.4   9.5  326   5.85
WQ G1820409 1506 2006  2400  230         9.2         1.5        1440   245
WQ G1820414 1200         50   19                                  25        14.5  6.9   8.4  517   4.92
WQ G1820416 0950         45   18                                  21        16.6  7.0   6.7  587   4.93
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WQ G1820421 1325         80   30                                  53        14.5  6.9   7.2  421   4.92
WQ G1820423 0830         50   24                                  27        12.0  6.7   6.7  468   4.89
WQ G1820426 1515         34   12   .15   2.0   1.7  0.25  0.08    14    48  16.1  7.3   9.3  521   4.87
WQ G1820430 1010         25   18                                   5        14.6  7.7  16.7  536   4.83
WQ G1820503 1135         65   50   .21   2.3   .68  0.16  0.02    15    48  17.6  7.7  11.2  577   4.81
WQ G1820505 1245         41   18                                 9.5        20.0  7.8  13.9  573   4.71
WQ G1820507 1120         22   19                                  12        17.5  6.9   6.5  513   4.94
WQ G1820510 1125         14    6                                   9        19.4  7.5   7.8  633   4.77
WQ G1820510 1140          8    5                                  13        19.9  7.9   8.8  513   0.01
WQ G1820512 1025         22    5                                 9.5        20.3  7.3   7.7  641   4.63
WQ G1820514 1015         26   14                                   5        19.7  6.9   3.1  650   4.56
WQ G1820517 1645         22    6   .26   2.2   .17  0.17  0.08     4    56  23.2  7.3   7.4  710   4.52
WQ G1820521 1110         16    8                                 5.3        21.2  6.9   2.3  695   4.58
WQ G1820524 1450          7    7                                 2.8        21.3  6.6   2.9  688   4.55
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WQ G1820528 1400         37   12                                   3
WQ G1820531 1945 0015  2200  230         6.1         1.1
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WQ G1820602 0530 0800    70   18
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WO G2R20218 1348         24   20                                   12                                 4.21
WO G2R20303 1015         25   10                                   15           4.2  7.5   10.7   322   2.67
WO G2R20305 1050        130   46                                   60           1.2  7.1   13.2   486   2.63
WO G2R20308 1220         20   12   3.0   5.0   1.2  0.70  0.44     11   47    2.5  7.9    9.8   463   2.45
WO G2R20310 1005          7    3                                  6.7           2.8  7.4          445   2.45
WO G2R20312 1545         75   31                                   59          10.4  6.8    9.1   337   2.61
WO G2R20312 1630         60   36                                               11.4  6.8   10.0   404
WO G2R20313 1310        280   65         4.6        1.00          230  117                            3.23
WO G2R20314 1600        110   35         3.8        0.68          120   87                            2.67
WO G2R20315 0920        260   36         3.9        0.86          195   85                            6.71
WO G2R20315 1126        210   48         3.4        0.84          170   97                            3.36
WO G2R20319 0940 1440   400   60         4.9         1.3          240  190                            4.14
WO G2R20320 0130 0600   190   35         4.1        0.80          150  110
WO G2R20320 1300 1800    90   22         2.3        0.70          100   80                            2.81
WO G2R20322 1325         55   17                                   24          11.5  7.1    6.6   366   2.53
WO G2R20325 1000 1400   490   70         2.8        0.68          225
WO G2R20325 2200 0400    90   18         2.5        0.78          150   72
WO G2R20326 1000 1400   105   23         2.6        0.67          110   68
WO G2R20326 1732         85   34                                   98           7.5  6.7   11.4   202   2.72
WO G2R20329 1850         85   27  0.52   4.5   1.3  0.61  0.22     44   66   11.1  7.1   10.9   316   2.48
WO G2R20331 1623         65   19                                   37          15.7  7.5    9.7   424
WO G2R20402 1108         36   11                                   23          14.6  7.3    7.4   530   2.41
WO G2R20402 2125 0225  1200  130         9.6         1.9         1640  325
WO G2R20403 0325 0825  1600  200         8.1         1.4         1060  190
WO G2R20404 1725 2225   560  110         4.6        0.99          550  110
WO G2R20405 1650        340   60                                  280           6.6  7.2    8.8   299   2.91
WO G2R20414 1100         25   23                                  2.5          14.4  6.8    8.9   558   2.52
WO G2R20416 0930         65   13                                   23          16.4  7.1    6.7   589   2.54
WO G2R20419 1340         80   22                                   75          14.0  6.8    5.1   363   2.59
WO G2R20421 1355         70   28                                   38          14.8  7.0    7.2   430   2.53
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WO G2R20423 0900                                                               12.4  7.1    7.5   422
WO G2R20428 1030         44   32   .56   2.5   1.3  0.36  0.16     15          16.2  7.4    9.1   519   2.49
WO G2R20430 1100         14    6                                   10          15.1  8.0   11.4   565   2.40
WO G2R20503 1055         22    8   .14   2.4   .22  0.22  0.07   13.0   42   18.4  7.8   11.2   579   2.39
WO G2R20505 1340         15   14                                    8          21.3  8.1   11.3   580   2.33
WO G2R20507 1030         28   14                                  7.2          16.8  7.1    5.9   498   2.55
WO G2R20510 1110         13   12                                  7.2          20.4  7.4    7.1   649   2.41
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WO G2R20514 1100                                                               21.6  7.3    8.6   657
WO G2R20517 1050         34    3   .14   2.4     0  0.29  0.07     12   50   22.8  7.3    4.5   710   2.34
WO G2R20521 1145         43   16                                   18          22.5  7.4    4.8   668   2.39
WO G2R20524 1645         28   18                                   16          22.5  7.4    5.2   574   2.37
WO G2R20528 1432         43   10                                  8.9
WO G2R20614 1513         60    9                                   16          28.1  6.7    3.3   448
WO G3R11209 1400         27    9                                   26
WO G3R20122 1552         52   31                                   11
WO G3R20125 1415         30   26   1.4   4.3   2.3  0.80           24   71    8.0  7.8   11.8   297
WO G3R20129 1720         55   29                                  110           8.1  8.2   10.8   291
WO G3R20130 1320        490   70                                  170
WO G3R20216 1430         25   14                                 19.5
WO G3R20217 1047         37    6                                   15
WO G3R20218 1500         24   19                                   15
WO G3R20303 1125         32   12                                   22           3.0  7.4   11.6   315   0.01
WO G3R20305 1015         25   14                                   23           1.7  7.5   17.5   352  -0.02
WO G3R20308 1345         21   13  0.57   2.1   2.1  0.27  0.22     16   42    4.1  8.5   12.7   469  -0.11
WO G3R20310 1025          8    2                                   12           4.1  7.2          413  -0.13
WO G3R20312 1605         44   27                                               11.4  6.9   10.0   337
WO G3R20313 1342        230   63         3.2        0.69          205  107                            0.33
WO G3R20314 1455         90   32         3.0         2.8          115   87                           -0.02
WO G3R20315 0932         95   36         3.0        0.59          165   72                            0.49
WO G3R20319 1000 1500   280   60         3.0        0.90               155                            0.69
WO G3R20320 0200 0700    60   17         2.8        0.60                73
WO G3R20320 1200 1800   100   36                                                                      0.09
WO G3R20321 1155        120   14                                   27          12.7  7.1    8.8   375  -0.10
WO G3R20325 0940 1340   320   70         3.4        0.80          210
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WO G3R20326 0940 1340    55   34         2.1        0.43           83   55
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WO G3R20331 1437         25   10                                   34                                -0.13
WO G3R20402 1052         22   10                                   32          15.8  7.7    8.3   469  -0.13
WO G3R20402 2115 0215  2500  240          12         1.5         1680  330
WO G3R20403 0315 0815   920  140         8.1         1.1         1080  220
WO G3R20403 1115 1615  1090  180         5.8         1.3         1000  209
WO G3R20404 0115 0615   380   70         5.1        0.83          475  120
WO G3R20404 0915 2415   200   50         4.8        0.65          295  115
WO G3R20405 1705        390   60                                  310           6.4  7.6   10.1   251   0.42
WO G3R20414 1150         30    9                                   16          14.3  7.4   10.1   500   0.04
WO G3R20416 0930         80   24                                   45          16.5  7.0    9.3   450   0.04
WO G3R20419 1315         85   18                                   95          14.1  6.9    7.8   323   0.09
WO G3R20421 1340         50   36                                   53          17.9  7.6   11.2   401   0.03
WO G3R20423 0350                                                               10.7  7.6   10.0   416
WO G3R20423 0350         36   10                                   35          10.7  7.6   10.0   416   0.03
WO G3R20426 1445         34   23   .20   1.4     0  0.12  0.03     26   48   17.7  7.6   11.5   441   0.02
WO G3R20430 1040         30   14                                  2.2          14.1  7.7    9.4   500   0.01
WO G3R20501 1200         19   11   .19   1.3     0  0.07  0.01     10   34   19.9  7.9    9.4 [illegible] 0.01
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WQ G3820510 1140                                           13      19.9  7.9   8.8  573
WQ G3820512 1010        14    2                           6.5      19.9  7.4   4.5  606  0.01
WQ G3820514 1030        14    3                           3.5      18.8  7.5   6.4  620  0.01
WQ G3820514 1100        55    8                            20      21.6  7.5   6.6  657  2.35
WQ G3820517 1725        20   10  .40  1.2    0 0.08 0.04  4.5  41  22.2  7.5   7.1  659  0.01
WQ G3820521 1130        65   12                            34      19.6  7.2   4.3  482  0.01
WQ G3820524 1500         4    2                             4      19.2  7.4   6.5  576  0.00
WQ G3820526 1050       170   17                             2
WQ G3820528 1415        25    4                           2.9
WQ G3820529 1500 1730  420   60       6.4       1.0       400
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WQ G3820607 1835 1905 1700  510                           220
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WQ G3820607 2035 2105 1900   90                           175
WQ G3820607 2135 2205 1200   48                           225
WQ G3820614 1621        38   10                           5.7      21.0  7.1   4.4  482  0.08
WQ SW820125 1545         8    6 0.12  0.7 0.77 0.04       4.9  19   2.7  7.9  12.8  177
WQ SW820129 1620        45   28                           3.9       3.7  7.7  12.3  226
WQ SW820130 1135        34   18                           6.2
WQ SW820130 1445        19    8                           4.5
WQ SW820303 1155        41   17                            20       2.4  6.9   7.8  100
WQ SW820305 1145        26   14                            27       3.1  6.0  12.3   96
WQ SW820308 1600        26   16 0.86  2.0 0.86 0.43 0.34   26  42   2.9  6.2   8.0  113
WQ SW820310 1115        18    7                            28       4.2  7.0        100
WQ SW820312 1500        22   11                            28       4.9  6.7   8.7   97
WQ SW820314 1720        33   20       2.1      0.41        28  45
WQ SW820315 1355        31   20       1.8      0.41        30  28
WQ SW820326 1600        36   16                            48      10.2  6.2  10.0  125
WQ SW820331 1545        55   16                                    11.8  7.4   9.3  140
WQ SW820402 1216        49   11                            56      12.2  6.8   6.1  168
WQ SW820405 1610       140   20                            97      10.4  7.0   8.3  176
WQ SW820415 0625        95    4                           110      10.4  7.1   8.7  186
WQ SW820416 1025        65   22                           130      11.4  6.6   8.4  187
WQ SW820419 1430        80   26                           130      13.5  6.8   7.1  187
WQ SW820421 1035       100   30                           140      14.2  6.4   7.8  180
WQ SW820423 1000       100   34                           150      13.8  6.8   7.4  183
WQ SW820426 1315                                                   16.2  6.5   7.0  183
WQ SW820430 1135        70   14                           110      14.5  7.0   7.1  189
WQ SW820503 1325        90   17  .40  2.0  3.7 0.29 0.04  150  63  14.8  6.2   4.5  186
WQ SW820505 1425        55   12                           150      15.3  6.8   3.1  192
WQ SW820507 1156        55   12                           145      18.5  7.0   7.3  164
WQ SW820510 1230        39    9                           125      18.2  7.1   6.9  198
WQ SW820512 1355        33   21                           150      19.8  7.2   8.3  206
WQ SW820514 1135        60   24                           150      19.6  7.0   6.1  200
WQ SW820518 0630        37   28  .32  1.9  2.1 0.23 0.05  150  54  20.6  7.2   6.4  215
WQ SW820521 1350        34   12                           130      21.0  6.6   5.4  207
WQ SW820524 1745        30    8                           110      22.9  6.9   5.7  212
WQ SW820526 1325        65   14                           140
WQ SW820614 1042        65   10                            95             6.4   4.0  205
WQ
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B102/10

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